# FOREWORD

This User's Guide discusses High Level Assembler Language (HLAL) as an effective programming tool for developing computer software more efficiently. It is intended for all programmers having basic knowledge of OS/360 Assembler Language.

Part I of this guide presents some of the basic ideas of Dr. Harlan Mills on structured programming. However, only those ideas applicable to the RTCC environment have been incorporated in HLAL. Therefore, this section is intended only to provide general background information supportive of the guidelines and detailed formulation of HLAL.

Part II discusses these guidelines in detail and provides a functional description of HLAL components. Included in the discussion are MACRO formats since HLAL makes extensive use of the OS/360 Assembler MACRO facilities and is essentially a MACRO language.

All sections are identified by a one-digit number in the upper righthand corner of the page. In Section 3 of Part II, the appropriate MACRO name has been added. These MACRO definitions are filed alphabetically and are page-numbered within to facilitate updating. Pages in all other sections are numbered consecutively.

Only current documentation is maintained in this book. All previous versions will be deleted as they become obsolete and filed in Records Retention. Any additions or changes to this guide may be directed to Will Taylor at 333-3300, extension 3519.

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# PART I. STRUCTURED PROGRAMMING

# 1. PRECISION PROGRAMMING

## 1.1 COMPLEXITY AND PRECISION IN PROGRAMMING

The digital computer has introduced a need for highly complex, precisely formulated, logical systems on a scale never before attempted. Systems may be large and highly complex, but if human beings, or even analog components, are intrinsic in them, then various error tolerances are possible, which such components can adjust and compensate for. However, a digital logic system, hardware and software, not only makes the idea of perfect precision possible - - it requires perfect precision for satisfactory operation. This complete intolerance to the slightest error gives programming a new character, unknown previously, in its requirements for precision on a large scale.

The combination of this new requirement for precision, and the commercial demand for computer programming on a broad scale has created many false values and distorted relationships in the past decade. They arise from intense pressure to achieve complex and precision results in a practical way without adequate theoretical foundations. As a result, a great deal of programming today uses people and machines highly inefficiently, as the only means presently known to accomplish a practical end.

It is universally accepted today that programming is an error-prone activity. Any major programming system is presumed to have errors in it. Only the very naive would believe otherwise. The process of debugging programs and systems is a mysterious art. Indeed, more programmer time goes into debugging than into program designing and coding in most large systems. But there is practically no systematic literature on this large undertaking. While a source of constant and deep frustration, such errors are nothing new in programming. They have always been there, from the very first days.

Yet, even though errors in program logic have always been a source of frustration, even for the most careful and meticulous, this may not be necessarily so in the future. Programming is very young as a human activity - - some twenty years old. It has practically no technical foundations yet. Imagine engineering when it was twenty years old. Whether that was in 1620 or 1770, it was not in very good technical shape at that stage either! As technical foundations are developed for programming, its character will undergo radical changes.

| Approval | Approval |
|---|---|
| William M. Taylor | S. E. James |

We contend here that such a radical change is possible now - - that the techniques and tools are at hand to permit an entirely new level of precision in programming. This new level of precision will be characterized by programs that ordinarily execute properly the very first time they are ever run. But to accomplish that level of precision, programming standards and disciplines will be required of an entirely new scope and depth, as well.

Note, here, the objectives of such precision in programming deal with execution, rather than assembly/compilations. Some improvement may be noticeable in reducing syntax errors, but assemblers/compilers can find syntax errors already. It is the program logic errors at the system level which can be practically eliminated from programming today.

## 1.2 KEY TECHNICAL PRINCIPLES

There have been, from the beginning of programming activities, certain principles from general systems theory that good programmers have identified and practiced in one way or another. These include developing systems designs from a gross level to more and more detail until the detail of a computer is reached, of dividing a system into modules in such a way that minimal interaction takes place through module interfaces, of creating standard subroutine libraries, and using high level programming languages for the coding process.

Precision in programming will see a reapplication of these classical ideas, such as program modularity and clean interface construction. However, there are also two key principles, which are new in their application to programming, that will play a major role in the implementation and exploitation of these ideas. These principles are based on new mathematical results, one graph-theoretic, one function-theoretic in character.

The first key technical principle is that the control logic of any program can be designed and coded in a highly structured way. In fact, we shall see that arbitrarily large and complex programs can be represented by iterating and nesting a small number of basic and standard control logic structures.

This principle has an analogue in hardware design where it is known that arbitrary logic circuits can be formed out of elementary "and", "or", and "not" gates. This is a standard in engineering so widespread it is taken

for granted. But it is based on a theorem in Boolean algebra that arbitrarily complex logic functions can be expressed in terms of "and", "or" and "not" operations. As such, it represents a standard based on a solid theoretical foundation. It does not require add hoc justification, case by case, in actual practice. Rather, it is the burden of a professional engineer to design logic circuits out of these basic components. Otherwise, considerable doubt would arise about his competence as an engineer.

A practical application of this first principle is writing "structured" programs - - e.g. GOTO-free PL/I programs (Dijkstra 1968). In PL/I, the branching control logic can be defined entirely in terms of DO loops, IF-THENELSE and ON statements. The resulting code can be read strictly from top to bottom, typographically, and is much easier understood thereby. It takes more skill and analysis to write such code, but its debugging and maintenance is greatly simplified. Even more importantly, such structured programming can increase a single programmer's span of detailed control and productivity by a large amount. Here as in circuit design, a theoretical result puts the burden on the programmer to produce GOTO-free code, rather than on case by case demonstrations by technical management.

The second key technical principle is that programs can be coded in a schedule that requires no simultaneous interface hypotheses. That is, programs can be coded in such a way that every interface is defined initially and uniquely in the coding process itself, and referred to thereafter only in its previously coded form.

This principle has an analogue in the theory of computable functions. A key point in characterizing a computable function is that its valuation can be accomplished in a sequence of elementary computations, none of which involves solving a simultaneous system of equations. Any program which is to be executed in a computer can be coded in such an execution sequence. And the very fact that the computer evaluates only computable functions means that no interfaces can be defined hypothetically and simultaneously in computation.

In practical application, this second principle leads to "top down" programming where code is generated in an execution precedence form. In this case, programmers write job control code first, then linkage editor code, then source code. The opposite (and typical implementation procedure) is "bottom up" programming, where source modules are written and unit tested

to begin with, and later integrated into subsystems and, finally, systems. This latter integration process, in fact, tests the proposed solutions of simultaneous interface problems generated by lower level programming; and the problems of system integration and debugging arise from imperfections of these proposed solutions. In a real sense, the usual system integration and debugging process seeks to solve sets of complex simultaneous interface equations which are created by the very system development process! Top down programming circumvents the integration problem by the coding sequence itself.

## 1.3 STANDARDS, CREATIVITY AND VARIABILITY

Many reactions to technical standards in programming make a basic confusion between creativity and variability. Programming these days is a highly variable activity. Two programmers may solve the same problem with very different programs. Two engineers asked to design a "half adder" with economical use of gates will be much less variable in their solutions, but, in fact, no less creative than two programmers in a typical programming project. Carried to an extreme, two mathematicians asked to solve a differential equation may use different methods of thinking about problems, but will come up with identical solutions and still be extremely creative in the process.

The present programming process is mostly writing down all the things that have to be done in a given situation. There are many different sequences which can accomplish the same thing in most situations. And this reflects itself in extreme variability. A major problem in programming at the present time is simply not to forget anything - - that is, to handle all possible cases and to invent any intermediate data needed to accomplish the final results. Thus, as long as programming is primarily the job of writing everything down in some order, it is, in fact, highly variable - - but that, in itself, is not creative.

It is possible to be creative in programming and that deals with far more ill-defined questions, such as minimizing the amount of intermediate data required, or the amount of program storage, or the amount of execution time, etc. Finding the deep simplicities in a complicated collection of things to be done is the creativity in programming. Getting a program to run correctly, handle all error conditions, etc., is like getting the ball in all 18 holes on a golf course. If you debug long enough, or hit the ball often enough, you get done. Only nobody asks in the clubhouse, "Did you get the ball in all 18 holes today?"

## 1.4 CONTROLLING COMPLEXITY THROUGH TECHNICAL STANDARDS

A major purpose in creating new technical standards in programming is to control complexity. Complexity in programming seems sometimes to be a "free commodity". It does not show up in storage or in throughput time, and it always seems to be something that can be dealt with indefinitely at the local level.

In this connection, it is an illuminating digression to recall that 500 years ago, no one knew that air had weight. Just imagine, for example, the frustrations of a water pump manufacturer then, building pumps to draw water out of wells on the "theory" that "nature abhors a vacuum". By tightening up seals, one can raise water higher and higher - - five feet, ten feet, then 15 feet, and so on, until one gets to 28 feet. But then, mysteriously and without seeming reason, no amount of effort avails to go higher. As soon as it is known that air has weight and it is, in fact, the weight of a column of some 28 feet of water, then the frustration clears up right away. Knowing the weight of air allows a better pump design, for example, in multiple stage pumps, if water has to be raised more than 28 feet.

We have a similar situation in programming today. Complexity has a "weight" of some kind, but we do not know what it is. We know more and more from practical experience that complexity will exact its price in a qualitative way, but we cannot yet measure that complexity in operational terms. For example, we are soldom able to intelligently reject a program module because it has "too many units of complexity in it". These units of measure will, in all probability, be in "bits of information". But just how to effect the measurements still requires development and refinement.

Nevertheless, we have qualitative notions of complexity, and standards can be used to control complexity in a qualitative way, whether we can measure them precisely or not. One kind of standard we can use to control complexity is structural, as in the first principle noted above. Then we can require that programs be written in certain structural forms rather than simply arbitrary complex control graphs generated at a programmer's fancy. The technical basis for the standard is to show that arbitrarily complex flowcharts can be reformulated in equivalent terms as highly structured flowcharts which satisfy certain standards.

# 2. STRUCTURED PROGRAMS

## 2.1 THE IDEA OF STRUCTURED PROGRAMS

We are interested in writing programs which are highly readable, whose major structural characteristics are given in hierarchical form. In fact, we are interested in writing programs which can be read sequentially in small segments, usually under a page in length, such that each segment can be literally read from top to bottom, with complete assurance that all control paths are visible in the segment under consideration.

There are two main requirements through which we can achieve this goal. The first requirement is GOTO-free code, i.e., the formulation of programs in terms of a few standard and basic control structures, such as IF-THEN-ELSE statements, DO loops, CASE statements, DECISION tables, etc., with no arbitrary jumps between these standard structures. The second requirement is library and macro substitution facilities, so that the segments themselves can be stored under symbolic names in a library and the programming language permits the substitution of any given segment at any point in the program by a macro-like call.

PL/I in OS/360 has both the control logic structures, and the library and macro facilities necessary. Assembler Language in OS/360 has the library and macro facilities available and a few standard macros can furnish the control logic structures required.

We will develop later a theoretical basis for programming without arbitrary jumps (i.e., without GOTO or RETURN statements) using only a set of standard programming figures, such as mentioned above. At the present time, we take such a possibility for granted, and note that any program, whether it be one page or a hundred pages, can be written using only IF-THEN-ELSE and DO loop statements for control logic.

The control logic of a program in a free form language, such as PL/I or PL360, can be displayed typographically, by line formation and indentation conventions. A Syntax-Directed Program Listing - - a formal description for such a set of conventions - - is given in (Mills 1970). Conventions often used are to indent the body of a DO-END block, such as

```
DO  I=J TO K;

    statement 1

    statement 2
      ...
    statement n

END;
```

and the clauses of IF-THEN-ELSE statements, such as

```
IF  X  >  1  THEN

    statement 1

ELSE

    statement 2.
```

In the latter case, if the statements are themselves DO-END blocks, the DO, END are indented one level, and the statements inside them indented further, such as

```
IF  X  >  1  THEN

    DO;

        statement 1

        statement 2
          ...
        statement k

    END;
```

```
ELSE
     DO;
          statement k + 1
             . . .
          statement n
     END;
```

In general, DO-END and IF-THEN-ELSE can be nested in each other indefinitely in this way.

## 2.2 SEGMENT STRUCTURED PROGRAMS

Imagine a hundred page PL/I program written in GOTO-free code. Although it is highly structured, such a program is still not very readable. The extent of a major DO loop may be 50 or 60 pages, or an IF-THEN-ELSE statement take up ten or fifteen pages. There is simply more than the eye can comfortably take in or the mind retain for the purpose of programming.

However, with our imaginary program in this structured form, we can begin a process, which we can repeat over and over until we get the whole program defined. This process is to formulate a one-page skeleton program which represents that hundred page program. We do this by selecting some of the most important lines of code in the original program and then filling in what lies between those lines by names. Each new name will refer to a new segment to be stored in a library and called by a macro facility. In this way, we produce a program segment with something under 50 lines, so that it will fit on one page. This program segment will be a mixture of control statements and macro calls with possibly a few initializing, file, or assignment statements as well.

The programmer must use a sense of proportion and importance in identifying what is the forest and what are the trees out of this hundred page program. It corresponds to writing the "high level flow chart" for the whole program, except that a completely rigorous program segment is written here.

A key aspect of any segment referred to by name is that its control should enter at the top and exit at the bottom, and have no other means of entry or exit from other parts of the program. Thus, when reading a segment name, at any point, the reader can be assured that control will pass through that segment and not otherwise affect the control logic on the page he is reading.

In order to satisfy the segment entry/exit requirement, we need only be sure to include all matching control logic statements on a page. For example, the END to any DO, and the ELSE to any IF ... THEN should be put in the same segment.

For the sake of illustration, this first segment may consist of some 30 control logic statements, such as DO-WHILE's, IF-THEN-ELSE's, perhaps another 10 key initializing statements, and some 10 macro calls. These 10 macro calls may involve something like 10 pages of programming each, although there may be considerable variety among their sizes.

Now we can repeat this process for each of these 10 segments. Again, we want to pick out some 50 control statements, segment names, etc., which best describe the overall character of that program segment and relegate further details to the next level of segments. We continue to repeat the process until we have accounted for all the code in the original program. Our end result is a program, of any size whatsoever, which has been organized into a set of named member segments, each of which can be read from top to bottom without any side effects in control logic, other than what is on that particular page. A programmer can access any level of information about the program, from highly summarized at the upper level segments to complete details in the lower levels.

In our illustration, this one hundred page program may expand into some hundred and fifty separate segments, because (1) the segment names take up a certain amount of space, and (2) the segments, if kept to a page maximum, may average only some two-thirds full on each page. Each page should represent some natural unit of the program, and it may be natural to only fill up half a page in some instances.

In the theoretical development carried out below, it will be apparent that it is possible to structure any given program much more deeply than that called for in maintaining segments to page sizes or less. The additional latitude in expanding a necessary half-dozen lines or so into some fifty, requires programmer creativity and perspective. It formalizes a process that good programmers do well instinctively and poor programmers do not so well. But it also standardizes this process of the selection of major from minor aspects of a program and allows all programmers to operate on a common base.

## 2.3 CREATING STRUCTURED PROGRAMS

In the preceding section, we assumed that a large size program somehow existed, already written with structured control logic, and discussed how we could conceptually reorganize the identical program in a set of more readable segments. In this section, we observe how we can create such structured programs a segment at a time in a natural way.

We suppose that a program has been well designed and that we are ready to begin coding. We also note a common pitfall in programming is to "lose our cool" - - i.e., begin coding before the design problems have been thought through well enough. In this case, it is easy to compromise a design because code already exists which is not quite right, but "seems to be running correctly"; the result is that the program gets warped around code produced ad hoc. We assume that has not happened here.

Our main point is to observe that the process of coding can take place in practically the same order as the process of extracting code from our imaginary large program in the previous section. That is, armed with a program design, one can write the first segment which serves as a skeleton for the whole program, using segment names, where appropriate, to refer to code that will be written later. In fact, by simply taking the precaution of inserting dummy members into a library with those segment names, one can compile or assemble, and even possibly execute this skeleton program, while the remaining coding is continued. Very often, it makes sense to put a temporary write statement "got to here OK" as a single executable statement in such a dummy member.

Now, the segments at the next level can be written in the same way, referring as appropriate to segments to be later written (also setting up dummy segments as they are named in the library). As each dummy segment becomes filled in with its code in the library, the recompilation of the segment that includes it will automatically produce new updated, expanded versions of the developing program. Problems of syntax and control logic will usually be isolated within the new segments so that debugging and checkout goes correspondingly well with such problems so isolated.

It is clear that the programmer's creativity and sense of proportion can play a large factor in the efficiency of this programming process. The code that goes into earlier sections should be dictated, to some extent, not only by general matters of importance, but also questions of getting executable segments reasonably early in the coding process. For example, if the control logic of a skeleton module depends on certain control variables, their declarations and manipulations may want to be created at fairly high levels in the hierarchy. In this way, the control logic of the skeleton can be executed and debugged, even in the still skeleton program.

Note that several programmers may be engaged in the foregoing activity concurrently. Once the initial skeleton program is written, each programmer could take on a separate segment and work somewhat independently within the structure of an overall program design. The hierarchical structure of the programs contribute to a clean interface between programmers. At any point in the programming, the segments already in existence give a precise and concise framework for fitting in the rest of the work to be done.

## 2.4 READING STRUCTURED PROGRAMS

Reading programs is as much an art today as writing them. There are as many ways of reading programs as there are programmers. Our objective is to develop a systematic basis for reading, so that the process is as nearly repeatable as possible; that is, so that two programmers would go through nearly the same activity in reading a given program and record the same set of observations about it.

As long as programs are the proverbial "bowls of spaghetti", there is little systematic that can be introduced into reading. It is simply a question of following threads of control and an a priori enumeration of that control is usually not practical. But when programs are structured as described above, then it is, indeed, possible to give a systematic sequence in which reading can be done. This sequence within each segment is strictly from top to bottom, noting, of course, the programming effect of the various figures encountered which cause branching and looping. The sequence between segments has more possible variety. These sequences correspond to alternatives available in conducting a tour through a tree. Systematic tree tours can be easily imagined in top down, bottom up, left to right forms, etc. For example, in a top down tour, one examines first the top node, then the nodes connected to that top node, then each of the nodes connected to the latter nodes, etc., until one has found all the nodes of the tree.

It is likely that both top down and bottom up tours will be useful in reading structured programs. When a programmer is trying to get acquainted with a program it seems that a top down reading sequence will be most instructive, so that the program unfolds much as it does in the writing process. However, when a programmer, or set of programmers, wants to do a thorough job of validating a program through reading, then it appears that a bottom up tour may be an effective way of proceeding. Each segment so read in the bottom up tour can be characterized as a checkpoint in the reading process so that the segments above which call on it will then be verifiable by using checkpoint information on the segments they name.

In this connection, it is important to observe that because of its one-in, one-out control character, a segment induces a change of state in the programming system and transfers control to the next line in the segment naming it. This change of state will be represented in changed data values in two categories of data; those internal to the segment (and therefore of no interest to the segment naming it) and data external to the segment. It is this external data that, when characterized, permits the segment to be read and its effects noted simply by name.

It is also evident that program segments, as we have defined them, are natural units of documentation and specification. In fact, the specification of a segment is the best means of accessing its function at higher levels in the

programming system. In this case, a reading checkpoint should contain the assertion that the segment carries out its specification correctly, subject, of course, to its named segments carrying out their specifications correctly as well. Now, if one begins at the bottom, verifies each segment carries out its specification and progresses upward, one can finally arrive at the full program as it has been checkpointed, and an opinion about its correctness.

Note again, as in the programming process, that this reading process can involve several programmers concurrently with the joint results being aggregated at higher levels into a final opinion about the program's correctness. Note also, unlike writing programs which seemingly have to be done by a single programmer, several programmers can be reading the same segments simultaneously to arrive at independent conclusions about their validity.

# 3. THE STRUCTURED PROGRAMMING PROCESS

## 3.1 FUNCTIONAL SPECIFICATIONS

We define a functional specification to correspond to the mathematical idea of a function, namely, a mapping of inputs into outputs, without regard to how that mapping is to be accomplished. In practical terms, of course, one has to have some underlying ideas on techniques and algorithms that are possible, in order to write a feasible functional specification. For example, we simply cannot formulate impossible computing processes as functional specifications without any hope of implementing them.

However, the general situation in programming system development is that the functional specifications are rather large and complex, simply to write them down. In illustration, the input and output messages and codes of a large information retrieval system may run to hundreds, or even thousands of pages. Because of this, functional specifications are seldom complete as mathematical descriptions, but nevertheless, the mathematical model is an ideal that we have in mind when we speak of functional specifications.

There is an additional advantage in defining a functional specification to correspond to the idea of a mathematical function. It represents a platform from which several independent alternative algorithmic approaches might be explored, even by different groups for later comparison and selection. It permits parallel efforts to an objective that is independent of the means.

Ordinarily, the development of functional specifications interact with the process of program design to achieve those specifications. In unique, highly specialized systems, program design may have a significant feedback to functional specifications to reflect certain opportunities available in hardware architecture or in a programming technique which the ultimate user can adapt to his needs in the programming system. For example, ultimate users can often view information systems in various, almost equivalent ways. In such cases, a particular indexing system already available may well affect the functional specifications for that user system.

## 3.2 FUNCTION EXPANSIONS

We have noted above that the top down programming process represents a step by step expansion of a mathematical function into simpler mathematical functions, using BLOCK, IF-THEN-ELSE, DO-WHILE, CASE, or DECISION statements as elementary structural devices. Such a programming process is easy to visualize with these constructs. Given a functional specification to be expanded by one step, we ask the question, "What elementary program statement can be used to expand the function?" The expansion chosen will imply one or more subsequent functional specifications, which arise out of the original specification. These new functional specifications can each be treated exactly as the original functional specification and the same questions posed about them.

As a result, the top down programming process is an expansion of functional specifications to simpler and simpler functions until, finally, statements of the programming language are reached. The beginnings of such a process is shown below, expanding the functional specification "Add member to library". Such a functional specification will require more description, but the breakout into subfunctions by means of programming statements can be accomplished as indicated here.

| | |
|---|---|
| f = "Add member to library" | (specification) |
| f = (BLOCK, g, h) | (expansion) |
| g = "Update library index" | (subspecification) |
| h = "Add member text to library text" | (subspecification) |
| g = (IF-THEN-ELSE, p, i, j) | (expansion) |
| p = "Member name is in index" | (subspecification) |
| i = "update text pointer" | (subspecification) |
| j = "Add name and text pointer to index" | (subspecification) |

etc.

----------

f = IF "Member name is in index" THEN (restatement of two levels of expansion)

"Update text pointer"

ELSE

"Add name and text pointer to index"

"Add member text to library text"

## 3.3 PROGRAM DESIGN

Good programmers have always organized large programming systems into a succession of subsystems of increasing detail with minimal interconnections between the subsystems. They also identify common subprocessing activities, if present, and formulate these as subroutines to be called throughout the programming system. We follow these ideas, sharpen them in some ways, because of the structured programs we intend to create.

First we make a distinction between subprograms which are created for structuring the system, and subprograms which carry out common low-level processing functions in many places in the system. The latter set of subprograms we isolate first, and append to the programming language itself, just as sine or exponential routines are regarded as part of PL/I or Fortran. These subprograms are documented and considered as part of the language description in which programmers write the programming system. It is natural to make these subprograms completely self-sufficient with respect to data, that is, to use no data from their environment except that passed explicitly in the arguments of their calls, Such subprograms may, in fact, be extensive and have their own private environment, e.g., it is conceivable that a subprogram accessed only by calls with explicit arguments may still access large masses of data in their execution, and that even large masses of data be identified in their argument list. But, nevertheless, the concept of data independence from the rest of the programming system is held.

The other type of subprogram which is used to help structure a system will ordinarily appear only once as a call from some other program. In this case, we use no arguments for the subprogram call, but let the communication between

programs be based entirely on data structures that both programs are aware of. Ordinarily, these data structures will be nested to correspond to the nesting structure of the programs themselves, and data scopes will be made as low as possible to localize their range of validity.

The process of program design is much influenced by the structured programs that are to result. For example, in defining a subsystem and the immediate constituents of that subsystem as smaller subsystems, one seeks enough control logic to fill up a page of conventional code, but not so much as to overflow pages. It takes some practice to accomplish this, but after some practice, it becomes easier than it might look to organize an entire programming system into a hierarchy of subsystems which are page-like segments in their final code. If, in the coding process, the coding estimates are greatly missed, some rethinking on the program design should be done and recoding carried out accordingly.

## 3.4 PROGRAM CODING

At the point in time when one is coding a segment, one has, in top down programming, sufficient information to write that segment correctly from code in higher levels which have already been written in order to reach this point of the coding. It is good practice to verify the code as it is written, for logical consistency, with previous code in terms of definitions, exact names, etc., line by line. Ordinarily, programmers do not imagine this kind of verification is really necessary, and rely on their short-term memories to put together and integrate sections of code written in a non-time-structured way. But there is nothing so sobering as programming in this way, discovering how often the short-term memory fails, and reflecting on how much additional debugging would have been necessary because of these failures. Programming today takes such additional debugging for granted, but it is not a necessary activity.

# PART II. HIGH LEVEL ASSEMBLER LANGUAGE

# 1. CONCEPTS

All frequently used segments of code are generated by MACROs. These include those that are common to all applications and those that fulfill individual requirements of each application. All MACROs are coded such that:

(a) They are self-documenting

(b) They are written to process higher level language type statements

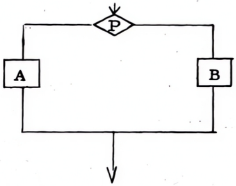
(c) The code that is generated to perform a given function is optimized and debugged when the MACRO is originally written, such that coding errors are reduced, resultant code is more efficient and the function does not have to be redesigned and rewritten each time it is used.

```
IF          BIT,X,IS,ON,THEN

ELSE

ENDIF
```

The common set of MACROs contains MACROs that define the beginning and ending block segments used for programming in the structured form.

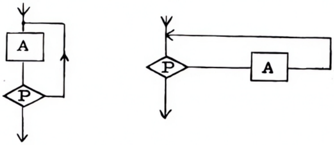
```
IF     P     THEN
       A
ELSE
       B
ENDIF
```

type: dual path decision logic



```
{UNTIL}   P     DO
{WHILE}
  A
ENDDO
```

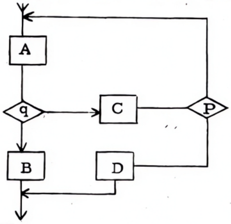
type: looping logic




---

```
STRTSRCH  (UNTIL)   P     DO
          (WHILE)
   A
EXITIF   q
   B
ORELSE
   C
ENDLOOP
   D
ENDSRCH
```

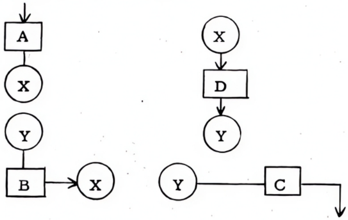
type: table search logic




---

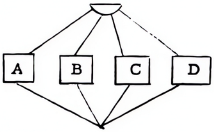
```
A
DO   X
B
DO   X
C
~
BGNSEG   X
D
ENDSEG
```

type: common code




---

CASE $5, AT=(A, B, C, D) type: multiple path decision logic




The common set of MACROs also contain MACROs that will perform both the standard logical and mathematical operations.

```
OIBIT     X                          - NIBIT
  ⸾                                  - XIBIT
X   BIT       0, ON                  - TMBIT
Y   BYTE
```

After data base is defined, bit manipulation is done without the need of byte masks (X '80')

```
MATH  '((A - B)  *  (C - D))/E = F'
```

mathematical operations.

The individual application set of MACROs will include MACROs which interface with supervisor services.

```
GWORK
RTWRITE
OPEN
```

All application MACROs are tailored to the formats, acronyms and language of that application.

```
GMCECNTL NAME = SING, INTERVL = 5, CHAIN = LAST
```

This is a specialized GSSC Skylab MACRO for resetting execution interval of a load module.

Except for the guidelines imposed by HLAL any code that can be written in basic Assembler Language can be generated with the block structured MACROs.

IF F,($5),EQ,($6),THEN

Register notation in IF MACRO

IF *,,IS,ZERO,THEN

Condition code has already been set.

All frequently used functions too large to expand directly into MACROs are designed and programmed as re-entrant routines which are invoked through tailored interface MACROs.

The set of MACROs needed to program a given area of an application are of such number that the learning time is relatively short.

Some form of block structured listing will be automatically produced each time a program is updated. (Pre- and post-Assembler Processors)

The use of HLAL requires as initial investment effort:

a. Generate the application oriented subset of MACROs (the common set are operational)

b. Educate all application programmers in their use and

c. Define the user data base and all interfaces with DSECTs and labels.

Experienced programmers (2 or 3) with extensive knowledge in the basic Assembler MACRO Language are needed to perform item a.

## 2. GUIDELINES

These following guidelines will be followed unless they result in gross inefficiencies in code. Any deviations will be discussed with and approved by the designated HLAL coordinator.

a. Should not modify executable code, except for moving a length field into a storage to storage instruction.

b. No conditional or unconditional branching. (The block structured MACROs generate all branching instructions.)

c. No programmer generated labels should be used for branching (the block structured MACROs generate all branching labels).

d. Code in straight forward, readable manner. (Do not get tricky.)

e. Do not use relative addressing (*+8). Do not use absolute displacements 28($5, $6) , use symbolic expressions X - Y ($5, $6) or Y($6) .

f. Reference registers by labels EQUed by HEADC or EQUATE MACROs: $0 - $15 for general purpose registers and FPR0 - FPR6 for floating point registers.

g. Data base and interfaces are referenced by labels defined in DSECTs.

These restrictions cause a programmer to generate straight forward code and avoid some features of basic Assembler Language that usually cause more trouble (excess debugging and non-readability) than they are worth in increased execution time efficiency.

# 3. MACRO FORMATS, DEFINITIONS AND EXAMPLES

The common HLAL MACROs are sub-divided into ten function groups:

a. Dual-path decision logic:

- IF
- ELSE
- ENDIF

b. Looping logic:

- UNTIL
- WHILE
- BGNWHILE
- ENDDO

c. Error checking logic:

- ERREXIT
- ERRENTER
- ERRMSG
- ERRETURN

d. Table search logic:

- STRTSRCH
- EXITIF
- ORELSE
- ENDLOOP
- ENDSRCH

e. Common code logic:

- DO
- BGNSEG
- ENDSEG

f. Multi-path decision logic:

- CASE

g. Entry, exit logic:

- HEADC
- ENTER
- EQUATE
- GRETURN

h. Bit manipulation:

- NIBIT
- OIBIT
- TMBIT
- XIBIT

i. Mathematical equations:

- MATH
- PRN, LENGTH, PARM } invoked by MATH

j. Data base definition:

- BIT
- BYTE

The formats, definitions, and examples of the MACROs follow, the MACROs ordered alphabetically. At the end of the MACRO definitions is a one page coding reference sheet for quick referral once a basic understanding of the MACROs is attained.

NAME - BGNSEG

DESCRIPTION

The BGNSEG MACRO generates a label for a section of code to be branched to by the DO MACRO.

The format is:

```
         BGNSEG    SEGMENT,REG
+SEGMENT    DS    OH
```

where SEGMENT is the name of the label to be generated and REG is the register to be used in returning from this segment of code.

When the BGNSEG MACRO follows a DO MACRO which references it, it will use the register specified in the DO macro. If the register is specified in the BGNSEG MACRO and it does not agree with the register specified in the previous DO MACRO, an error message will be written.

When the BGNSEG MACRO precedes any DO MACRO reference to it, the register will default to $14 unless a register is specified.

A maximum of 50 segments may appear in an assembly. Registers need to be expressed in notation $1, $2 etc.

EXAMPLES

Example 1

```
                  BGNSEG      COMPUTE
   +COMPUTE       DS          OH
                  ⌠
                  ENDSEG      COMPUTE
   +              BR          $14
```

Example 2

```
                 DO          CODE, $6
+                BAL         $6, CODE
                  }
                 BGNSEG      CODE
+CODE            DS          OH
                  }
                 ENDSEG      CODE
+                BR          $6
```

NAME - BGNWHILE

DESCRIPTION

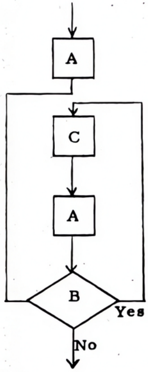
(BGNWHILE (no operands))

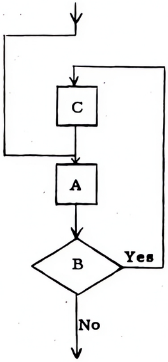
The BGNWHILE macro will cause execution of a WHILE loop to begin at the instruction immediately following the BGNWHILE macro. This macro should be preceded by a WHILE macro and succeeded by an ENDDO macro. Normally, a WHILE loop begins at the ENDDO macro by checking the condition specified in the WHILE macro.

The following example illustrates how a BGNWHILE would be used to start execution of a loop between the WHILE and ENDDO macros.

Instruction Sequence

| Without BGNWHILE | With BGNWHILE |
|---|---|
| [A] | |
| WHILE ( [B] ), DO | WHILE ( [B] ), DO |
| [C] | [C] |
| [A] | BGNWHILE |
| ENDDO | [A] |
| | ENDDO |


A
C
A
B
Yes
No


C
A
B
Yes
No

NAME - BIT

DESCRIPTION

The purpose of the BIT macro is to generate a data base definition whose length can be used as a key to test or manipulate a specific bit in a byte.

DEFINITION

| | | |
|---|---|---|
| symbol | BIT | {Bit number, or list of bit numbers, or binary 8-bit configuration} [,ON] |

where

- symbol -- any valid non-blank label. If omitted, an error condition will be raised with a condition code of 12.

- bit number -- an unsigned decimal integer, 0 through 7, representing standard bit notation.

- list of bit numbers -- a list of bit numbers separated by commas. The entire list must be enclosed by parenthesis.

- binary 8-bit configuration -- notation of the form B'XXXXXXXX', where X is 1 if the corresponding bit is to be represented by this label and X is 0 if the corresponding bit is not to be represented by this label.

- ON -- indicates the bit or bits indicated in the first operand are to set to 1 in a global variable which is passed to the BYTE macro.

FUNCTION

**The BIT macro performs its operations as follows:**

- **checks to see if there is a valid non-blank label attached to the macro.**
- **processes the information passed by the first operand, checking each time for an invalid bit number or binary character.**
- **generates a DS and ORG statement to establish a length which can be used to test or manipulate bit(s), and reset the location counter setting. (There is an exception to this -- if the** name of the CSECT currently being processed starts with SCDB, the DS and ORG **statement will not be generated.**

EXAMPLES OF THE USE

**The following are included to give the user a feeling of what can and cannot be done with the BIT macro:**

**Example 1**

| NAME | OPERATION | OPERANDS |
|---|---|---|
| FIRST | BIT | 0 |
| +FIRST | DS | XL(B'10000000') |
| + | ORG | *-B'10000000' |

**Example 2**

| NAME | OPERATION | OPERANDS |
|---|---|---|
| SECOND | BIT | (0, 1, 5, 7), ON |
| +SECOND | DS | XL(B'11000101') |
| + | ORG | *-B'11000101' |

**Note: In the above example, specifying 'ON' had no effect upon the expansion of the macro.**

Example 3

| NAME | OPERATION | OPERAND |
|---|---|---|
| THIRD | BIT | B'00111100' |
| +THIRD | DS | XL(B'00111100') |
| | ORG | *-B'00111100' |

The following examples would raise error conditions:

| CODING | | | CAUSE OF ERROR |
|---|---|---|---|
| NAME | OPERATION | OPERAND | |
| | BIT | 0 | name field blank |
| ONE | BIT | 0, 1, 2 | operand not enclosed in parentheses |
| TWO | BIT | 8 | operand is greater than 7, does not satisfy standard bit notation |
| THREE | BIT | '01010101' | improper binary notation, should be B'01010101' |
| FOUR | BIT | ,ON | first operand missing |

GENERAL NOTES

- All errors detected by the BIT macro will raise a condition code of 12 and result in the termination of processing by the macro. No DS and ORG will be generated unless the operand(s) are valid.

- Specifying 'ON' is used only in conjunction with the BYTE macro. Nothing is gained by the user in using this if the BYTE macro is not also included in his program.

NAME - BYTE

DESCRIPTION

The purpose of the BYTE macro is to generate a data base definition using either information passed from previous calls of the BIT macro or a parameter on the BYTE macro.

DEFINITION

| | | |
|---|---|---|
| symbol | BYTE | one byte hex value |

where

- the operand may be blank, or
- the operand is a value hexadecimal number (range is from $0_{10}$ to $255_{10}$) i.e., X'FF'.

FUNCTION

The BYTE macro performs its operations as follows:

- examines the operand to determine whether or not it is null.
- if the operand is null, the BYTE macro builds a DC using information passed from previous calls of the BIT macro.
- if the operand is present, BYTE generates a DC statement using this parameter.

## EXAMPLES OF THE USE

Use with a non-blank parameter.

| NAME | OPERATION | OPERAND |
|---|---|---|
| FIRST | BYTE | X'CF' |
| +FIRST | DC | X'CF' |

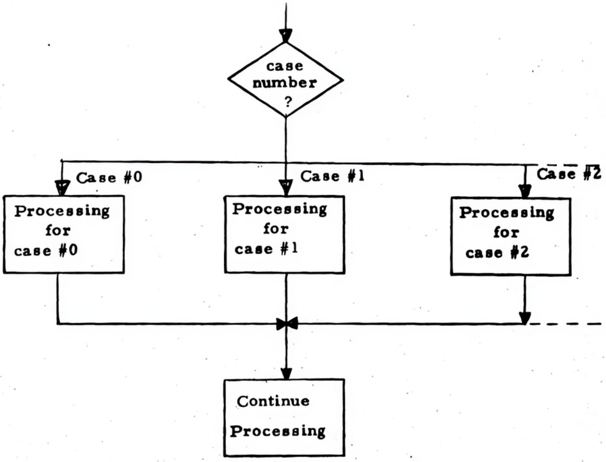
Use in conjunction with the BIT macro

| NAME | OPERATION | OPERAND |
|---|---|---|
| BIT1 | BIT | 0 |
| + BIT1 | DS | XL(B'10000000') |
| + | ORG | *-B'10000000' |
| BIT3 | BIT | 2,ON |
| + BIT3 | DS | XL(B'00100000') |
| + | ORG | *-B'00100000' |
| BIT5 | BIT | B'00001000',ON |
| + BIT5 | DS | XL(B'00001000') |
| + | ORG | *-B'00001000') |
| BIT78 | BIT | (6, 7),ON |
| + BIT78 | DS | XL(B'00000011') |
| + | ORG | *-B'00000011' |
| ALL | BYTE | |
| + ALL | DC | B'00101011' |

NAME - CASE

DESCRIPTION

The purpose of this macro is to generate the code necessary for certain, frequently encountered, decision table type processing logic. In this type of processing one usually has a case (index) number in some GPR and desires to execute one of a list of options (cases) based upon the value of the case number in the GPR. The following block diagram shows the basic flow of this type of logic:



In this macro it is assumed that the increment between the case numbers is a power of two (i.e., 1, 2, 4, 8, . . .) and that the cases are numbered starting with zero. It should be noted that CASE loads the specified RETREG with the address of the instruction following the macro before branching to the determined case; and, it is the responsibility of each case to return to the address specified in the RETREG (if the requirements of structured coding are to be fulfilled). The following shows the formats of the CASE macro:

| | | |
|---|---|---|
| [symbol] | CASE | case register, { AT = (address list)<br>BT = (address list)<br>(R)<br>LAT = addr.<br>(R)<br>LBT = addr. } [,INDX=number]<br>[,RETREG=register] |

case register -
is the register number (or symbol equated to the register number) of the GPR that contains the desired case number. This must not be the same register that is used as the RETREG.

AT = (address list) -
is a list of up to 255 case labels. This list of case labels is used to generate a corresponding list of address constants. When this form of the CASE macro expands the case register will be used to index into this list of ADCONS, inorder to determine which case is to be branched to. There is a one-to-one correspondence between a labels position in the list and its associated case number (i.e., the first label in the list is the name of the case which is to receive control when the case register contains a zero. If a label is left null an address of zero will be generated for the associated case number. (This should be used for any embedded cases numbers, which are not expected to occur and which a program check is desired if it ever does occur). An * may be coded in place of any of the labels to signify that processing is just to continue at the instruction following the macro when the associated case(s) occurs. It should be noted that by specifying one or more of the labels (used in an AT type expansion) in an EXTRN statement, the CASE macro becomes effectively an indexed CALL macro.

BT = (address list) -

is a list of up to 255 case labels, as defined for the AT type expansion. The only difference between the AT and the BT type expansions is that BT generates a branch table instead of an address table for the labels specified. This permits the use of case labels that are not in the same CSECT nor callable, but for which a base register is set up.

LAT = addr. (R) -

is the address of a remote list address table to be used by CASE in determining where to branch for each value that can be placed in the case register. This address may be specified in a register as (R) where R is some register number (not being used as a case register or a RETREG).

LBT = addr. (R) -

is the address of a remote list of branch instructions to be used by the CASE in branching to the case designated by the value in the case register. As in LAT this address may also be specified in a register form.

INDX = number

is used to specify the increment used in counting the cases. This must be some power of 2 (i.e., 1, 2, 4, 8, 16, 32, . . .). The default for INDX is 4. (This says that the cases are numbered 0, 4, 8, 12, 16, . . .).

RETREG = register -

is used to specify the register to be setup as the linkage register on the branch. This is specified as any register number or symbol equated to a register number. The default for RETREG is 14.

EXAMPLES OF USE

In the following examples NUM is equated to a GPR that contains the case number.

```
 XXX         CASE     NUM,AT=(*,MUD,,GARB)
+            CNOP     0,4
+XXX         BAL      14,*+20
+            DC       A(*+10+4*(4-1))
+            DC       A(MUD)
+            DC       A(0)
+            DC       A(GARB)
+            L        15, 0(14,NUM)
+            BALR     14,15
```

```
 XXX         CASE     NUM,BT=(*;MUD,,GARB)
+XXX         LA       14,*+4+20
+            B        *+4(NUM)
+            B        *+4+4*(4-1)
+            B        MUD
+            DC       A (0)
+            B        GARB
```

```
 XXX         CASE     NUM,LAT=($10),RETREG=$8,INDX=1
+XXX         SLL      NUM,2
+            L        15,0(NUM,$10)
+            BALR     $8,15
```

```
 XXX         CASE     NUM,LBT=MUD,INDX=32,RETREG=$9
+XXX         SRL      NUM,3
+            BAL      $9,MUD(NUM)
```

NAME - DO

DESCRIPTION

The DO MACRO generates a branch-and-link to a segment of code, defined by the BGNSEG and ENDSEG MACROs.

The format of the DO MACRO is:

```
    DO     SEGMENT,REG
+   BAL    REG,SEGMENT
```

where SEGMENT is the label of the section of code to be branched to and REG is the register to be used. If the register is not specified, register 14 will be used.

If the register to be used in branching to and from a segment has already been defined by a previous DO or BGNSEG MACRO, issuing a different register will cause an error message to be printed. Registers need to be expressed in notation $1, $2 etc. A maximum of 50 segments may appear in an assembly.

EXAMPLES

Example 1

```
                 DO        COMPUTE
+                BAL       $14, COMPUTE
                  }
                 BGNSEG    COMPUTE
+COMPUTE         DS        OH
                  }
                 ENDSEG    COMPUTE
+                BR        $14
```

Example 2

```
                    DO          CODE,$6
+                   BAL         $6,CODE
                    ⌇
                    BGNSEG      CODE
+CODE               DS          OH
                    ⌇
                    ENDSEG      CODE
+                   BR          $6
                    ⌇
                    DO          CODE,$7
+     4,****        WRONG REGISTER HAS BEEN SPECIFIED
```

NAME - ELSE

DESCRIPTION

The function of the ELSE macro is to generate the branch and labels that correspond with the branch instructions generated by the IF macro and the labels generated by the ENDIF macro. See the IF macro.

NAME - ENDDO

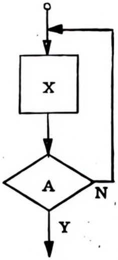
DESCRIPTION

**The function of the ENDDO macro is to generate the labels that correspond to the labels and instructions generated by the WHILE/UNTIL macros. See the WHILE or UNTIL macros.**

**UNTIL A,DO**

**X**

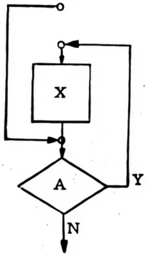
**ENDDO**




**WHILE A,DO**

**X**

**ENDDO**

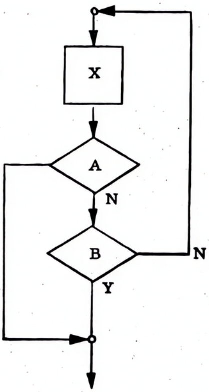



**UNTIL A,OR**

**UNTIL B,DO**

**X**

**ENDDO**

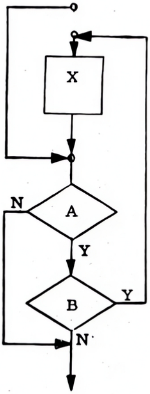



**WHILE A,AND**

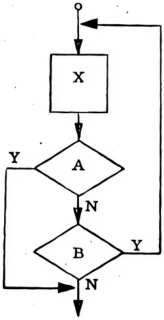
**WHILE B,DO**

**X**

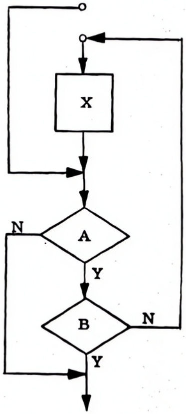
**ENDDO**



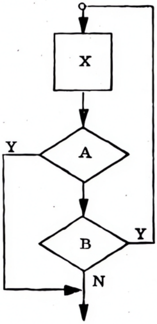
```
UNTIL  A,AND
WHILE  B,DO
  X
ENDDO
```



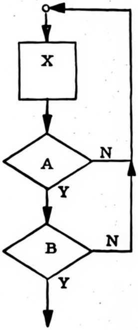

```
WHILE  A,AND
UNTIL  B,DO
  X
ENDDO
```




```
UNTIL  A,OR
WHILE  B,DO
  X
ENDDO
```




```
UNTIL  A,AND
UNTIL  B,DO
  X
ENDDO
```

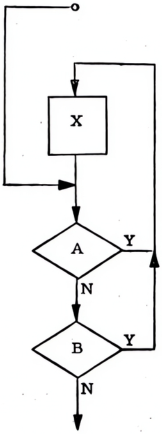


WHILE A,OR

WHILE B,DO

X

ENDDO

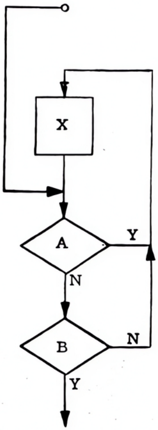



WHILE A,OR

UNTIL B,DO

X

ENDDO




NOTES: In an UNTIL a BCT = yes when the register = 0 after execution of BCT.
In a WHILE a BCT = no when the register = 0 after execution of BCT.

NAME - ENDIF

DESCRIPTION

The function of the ENDIF macro is to generate the labels that correspond with the branch instructions generated by the IF macro. See the IF macro.

NAME - ENDLOOP

DESCRIPTION

The function of the **ENDLOOP** macro is to define the end of the loop. See the **STRTSRCH** macro.

NAME - ENDSEG

DESCRIPTION

The ENDSEG MACRO generates a BR instruction. It is used to return from a segment of code that has been branch-and-linked to by the DO MACRO.

The format is:

```
                    ENDSEG      SEGMENT
+                   BR          REG
```

where SEGMENT is the name of the segment to be terminated and REG is the register to be used. The register is determined by either a previous DO or BGNSEG MACRO.

EXAMPLES

Example 1

```
                    BGNSEG      COMPUTE, $6
+COMPUTE            DS          OH
                    }
                    ENDSEG      COMPUTE
+                   BR          $6
```

Example 2

```
                    DO          CODE, $7
+                   BAL         $7, CODE

                    BGNSEG      CODE
+CODE               DS          OH

                    ENDSEG      CODE
+                   BR          $7
```

NAME - ENDSRCH

DESCRIPTION

The function of the ENDSRCH macro is to indicate the end of the complete macro set. See the STRTSRCH macro.

NAME - ENTER

DESCRIPTION

The 'ENTER' macro is used to generate multiple - entry point code. The macro generates:

1. One CSECT card (CSECT name = 1st subparameter of the first operand.)
2. An "ENTRY" card for each entry point
3. One save area (22wds if 'INTP' appears in col. 1-4)* and 'SAVE' code which establishes R13 as a base register.
4. A label to branch to 'RETURN' (label = an 'R' concatenated with the CSECT name)
5. '$0 EQU 0', . . . , '$15 EQU 15' so that an XREF is given of Register usage if the $XX symbols are used to specify registers. (The 'EQU's are generated only once per assembly even though more than one 'ENTER' is coded.)
6. Register 15 is loaded with the address of the code associated with the resp. entry point (i. e., the resp. name specified in the second operand sublist - if left blank, '$' is concatenated with the resp. entry point specified in the first operand sublist) so that one executes 'BR $15' after executing code which is common for all entry points.

EXAMPLE OF USE

```
INTP    ENTER   (X, Y, Z), (, ZINTRNAL)
        SR $7, $7           ** FOR LATER USE
        L $12, =V(MGLBAT)
        L $12, $12, 0($12)
        L $10, 4*X'2D'  ($12)
        USING SBL2DA, $12
        TC INTP
        BR $15
```

* See Reference 4, for discussion of INTP.

```
$X        DS      OH
          GSIN    A
          STE     O,B
          B       GOTIT
$Y        GSIN    AA
          STE     O,B
          ST      $7,Q      Q=0
          B       GOTIT
ZINTRNAL  GSIN    AA
          STE     O,B
GOTIT     EQU     *
            {
```

NAME - EQUATE

DESCRIPTION

The 'EQUATE' macro is used to generate '$0 EQU 0' . . . '$15 EQU 15' and 'FPRO EQU 0' ... 'FPR6 EQU 6' statements by both the 'HEADC' and 'ENTER' macros. In a CSECT which does not require a save area (and hence wouldn't use' HEADC' or 'ENTER'). one may use 'EQUATE' itself to get the EQU's generated.

EXAMPLE OF USE

```
X          CSECT
           EQUATE
+$0        EQU 0
+$1        EQU 1
             {
+$15       EQU 15
+FPRO      EQU 0
+FPR2      EQU 2
+FPR4      EQU 4
+FPR6      EQU 6
           STM $14, $12, 12 ($13)
           USING X, $15
             {
           END
```

NAME - ERRENTER

DESCRIPTION

ERRENTER &A

&A = a symbol not greater than four characters in length.

The ERRENTER macro should be used to begin a segment of special error processing for a particular error designated by &A, which should have been specified in an ERREXIT macro. The segment should end with (1) an ERRMSG macro for an error message if one is required, (2) another ERRENTER macro for a different error condition, or (3) the ERRETURN macro.

If the ERRENTER macro is preceded by another ERRENTER macro (with no ERRMSG macro between the two), it will expand to a branch to ERRETURN prior to defining the error symbol. Otherwise, it will merely expand to a definition of the error symbol.

The following example shows how ERRENTER would be used to process special error conditions.

Suppose there are three error conditions (ER1, ER2, ER3), one which requires an error message only, one which requires special processing only, and one which requires special processing and an error message. The following code demonstrates the use of ERRENTER in conjunction with the other ERROR MACROS to accomplish these results:

```
          body of csect with ERREXIT macros
            to ER1, ER2, ER3)

GRETURN
ERRMSG ER1
DC   C'(error message for er1)'
ERRENTER ER2
              (special processing for er2)
ERRENTER ER3
              (special processing for er3)
ERRMSG
DC   C'(error message for er3)'
ERRETURN
              (common error processing)
GRETURN
```

This code would expand as follows:

```
                 (body of csect with ERREXIT macros to ER1, ER2, ER3)
            GRETURN
+           B      R&SYSECT
            ERRMSG  ER1
+ERXTER1    BAL  0,ERREXIT$
            DC   C' (error message for er1)'
            ERRENTER ER2
+ERXTER2    DS     0H
                 (special processing for er2)
            ERRENTER ER3
+           B      ERREXIT$
+ERXTER3    DS     0H
                 (special processing for er3)
            ERRMSG
+           BAL        0,ERREXIT$
            DC   C' (error message for er3)'
            ERRETURN
+ERREXIT$   DS     0H
                 (common error processing)
            GRETURN
+           B      R&SYSECT
```

NAME - ERRETURN

DESCRIPTION

ERRETURN

The ERRETURN macro expands to a definition of the symbol ERREXIT$. The ERRETURN macro should be used to begin common error processing. See the ERRENTER macro for examples of its use.

NAME - ERREXIT

DESCRIPTION

ERREXIT &A, &B, &C, &D, &E, &F, &G

&A = 'IF' / SYMBOL

If a symbol is coded for &A, it must be not greater than 4 characters long and it should be the operand of an ERRENTER or ERRMSG macro elsewhere in the CSECT. &B - &G will be ignored, and the macro will generate a BC 15, ERXT (symbol).

If &A = IF, then the operands &B - &G should be coded exactly as they were operands of an IF macro with the exception of &F. &F is normally 'THEN', 'AND', or 'OR' in the IF macro, but it should be a symbol not greater than four characters long in the ERREXIT macro and the same symbol should be the operand of an ERRENTER or ERRMSG macro elsewhere in the program.

Using ERREXIT in case 2 will expand into the same code that the IF macro does except for the BRANCH instruction generated by IF. Instead it will generate a BRANCH to the symbol ERXT(symbol)on the condition specified by the operands &B - &E. (No ENDIF should be associated with an ERREXIT macro).

Example 1:

```
           ERREXIT  IF,F,($3),IS,ZERO,REGZ
+          LTR      $3,$3
+          BC       8,ERXT REGZ
              ⋮
           ERRMSG   REGZ
+ERXTREGZ  BAL      0,ERREXIT$
           DC       C'cannot specify zero reg' (error message)
              ⋮
```

```
          ERRETURN
+ERREXIT$ DS   0H
          PUT  ERDCB,(0)
          GRETURN
+         B    R&SYSECT
```

Example 2:

```
          ⋮
          ERREXIT  ERR2
+         BC   15,ERXTERR2
          ⋮
          ERRENTER  ERR2
+ERXTERR2 DS   0H
          ⋮   do special error processing
          ERRMSG
+         BAL  O,ERREXIT$
          DC   C' (error message)'
          ERRETURN
+ERREXIT$ DS   0H
          ⋮   do common error processing
          GRETURN
+         B    R&SYSECT
```

NAME - ERRMSG

DESCRIPTION

ERRMSG &A [, &B]

&A = a symbol not greater than 4 characters in length
&B = a register number (defaults to 0)

The ERRMSG macro should be used to define an error message for the error condition designated by &A. &A should be left blank if the error condition was designated by an ERRENTER macro (with the associated special error processing) immediately preceding the ERRMSG macro.

The error link register is specified by &B and should be specified only by the first ERRMSG macro in the CSECT. &B will then default to that of the first ERRMSG macro for subsequent ERRMSG macros and will default to 0 on the first ERRMSG macro if not specified.

The ERRMSG macro expands to a BAL off the error link register to ERRETURN, defining the BAL instruction with the error symbol, if one is specified.

See the ERRENTER macro for examples.

NAME - EXITIF

DESCRIPTION

The function of the EXITIF macro is to test a condition to see whether to continue the loop or exit out of the loop. See the STRTSRCH macro. The following shows the format of the EXITIF macro.

```
                              ⎧ OR   ⎫
EXITIF     [condition]   ,   ⎨ AND  ⎬   [, REG= ]
                              ⎩ THEN ⎭
```

The condition format is the same as the IF macro except that the label IF is not specified.

NAME - GRETURN

DESCRIPTION

The GRETURN macro expands to a B R&SYSECT. It should be used in conjunction with the HEADC and ENTER macros.

NAME - HEADC

DESCRIPTION

HEADC will generate the CSECT card, save area, entry coding, and return coding for a single entry point Assembler Language program. It will also invoke the EQUATE macro.

The HEADC macro is written as follows:

CSECT name HEADC [INTP = YES]* [, RET = YES]

"CSECT name" will be the name on the generated CSECT card and the entry point for the program. If INTP = YES is coded, a 22-word save area will be generated in place of the standard 18-word save area. A 22-word save area is needed if the program INTP is used

If RET = YES is coded, register 15 will not be restored as part of the return logic, allowing the programmer to store a return code in that register. INTP = YES and RET = YES are not positional parameters; they are keyword parameters.

HEADC will point GPR 13 to the save area and do a 'USING' on GPR 13 so that it will serve as the base register for the program. The return logic can be reached by branching to the label RCSECT name. If this label is more than eight characters, the right-most character is truncated in the generated macro label, and an assembly error is flagged in the 'B RCSECT' statement. To avoid the error message, the programmer should truncate RCSECT to eight characters in coding the 'B RCSECT' statement.

EXAMPLE OF USE

Example 1

```
MUD        HEADC
           {  other code
           B RMUD
```

* See Reference 4. for discussion of INTP.

Example 2

```
MUDAGARB  HEADC     INTP = YES
                    {
          TC          INTP
                    {
          B         RMUDAGAR
```

Example 3

```
MUD3      HEADC     RET = YES
          {
          L         $15,=F'2'
          B           RMUD3
```

NAME - IF

DESCRIPTION

The function of the IF macro is to generate the labels and instructions that branch to these labels to accomplish the IF-THEN, IF-AND-THEN, IF-OR-THEN, IF-THEN-ELSE, IF-AND-THEN-ELSE, and IF-OR-THEN-ELSE programming functions.

THE IF MACRO SPECIFICATIONS

There are six different IF statements. They are: IF-THEN, IF-AND-THEN, IF-OR-THEN, IF-THEN-ELSE, IF-AND-THEN-ELSE, and IF-OR-THEN-ELSE.

The format for the IF-THEN is:

```
 IF condition

   code - body
  ENDIF
```

which reads "IF the tested condition is true, then execute the code-body."

The format for the IF-AND-THEN is:

```
 IF condition, AND
 IF condition, THEN

   code - body
  ENDIF
```

which reads "IF both conditions are satisfied, then execute the code-body."

The format for the IF-OR-THEN is:

```
 IF condition, OR
 IF condition, THEN

   code - body

 ENDIF
```

which reads "IF either condition is satisfied, then execute the code-body."

The format for the IF-THEN-ELSE is:

```
IF condition, THEN

  code - body1

ELSE

  code - body2

ENDIF
```

which reads "IF the condition is true, THEN execute code-body1, ELSE execute code-body2.

The format for the IF-AND-THEN-ELSE is:

```
IF condition, AND
IF condition, THEN

  code - body1

ELSE

  code - body2

ENDIF
```

whech reads "IF both conditions are satisfied, THEN execute code-body1, ELSE execute code-body2.

The format for the IF-OR-THEN-ELSE is:

```
IF condition, OR
IF condition, THEN

  code-body1

ELSE

  code-body2
```

ENDIF

which reads "IF either condition is satisifed, THEN execute code-body1, ELSE execute code-body2.

THE IF MACRO FLOWCHARTS

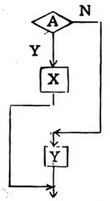
IF A, THEN

X

ELSE

Y

ENDIF




IF A, AND

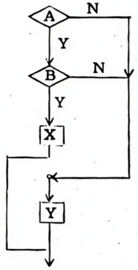
IF B, THEN

X

ELSE

Y

ENDIF



IF A, OR

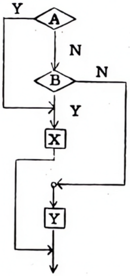
IF B, THEN

X

ELSE

Y

ENDIF




The following shows the format of IF.

IF [ * | BIT | B | H | F | E | D | T | C ] ,(R1) / ,LABEL1, { IS | GT | LT | GE | LE | EQ | NE } , [ (R2) | LABEL2 | ONE(S) | OVERFLOW | PLUS | MINUS | MIXED | ZERO(S) | NMINUS | NPLUS | NONE(S) | NZERO(S) | OFF | ON ] , { AND | OR | THEN } [, REG= ]

IF [TYPE] ,LABEL, OPERATION, CONDITION, { AND | OR | THEN } [, REG= ]

The different types are:

1. An * in the type field stands for the condition is already set. When using the * type, the Operation and Condition Fields cannot be omitted.

   Examples:

```
     IF *,,IS,PLUS,THEN
+    BC 13,LABEL
     CODE-BODY
     ENDIF
+LABEL EQU *
```

```
    IF   *,,EQ,LABEL,THEN
+   BC   7,LABEL1
    CODE-BODY1
    ELSE
+   B    LABEL2
+LABEL1  EQU *
    CODE-BODY2
    ENDIF
+LABEL2  EQU *
```

2. Bit type: will generate a test under mask. The only valid operation parameter is (IS) and the only valid condition parameters are: ZERO, ONE, ON, OFF, MIXED, NONES, NMIXED, and NZERO.

```
                         ⎧ ZERO   ⎫
                         ⎪ ONES   ⎪  ⎧AND ⎫
    IF  BIT, LABEL, IS,  ⎨ ON     ⎬, ⎨OR  ⎬
                         ⎪ OFF    ⎪  ⎩THEN⎭
                         ⎪ MIXED  ⎪
                         ⎪ NONES  ⎪
                         ⎪ NMIXED ⎪
                         ⎩ NZERO  ⎭
```

Examples:

```
    IF  BIT,A,IS,ZERO,THEN
+   TM   A,L'A
+   BC   7,LABEL
    CODE-BODY
    ENDIF
+LABEL  EQU *
```

3. B type:

```
                          ⎧ ZERO(S)  ⎫
                          ⎪ PLUS     ⎪
                          ⎪ MINUS    ⎪     ⎧AND ⎫
    IF  B,LABEL1,IS,      ⎨ NPLUS    ⎬  ,  ⎨OR  ⎬
                          ⎪ NMINUS   ⎪     ⎩THEN⎭
                          ⎩ NZERO(S) ⎭
```

```
                   { GT }   { T '       }
                   { LT }   { L '       }
                   { EQ }   { X '4F'    }    { AND  }
IF  B, LABEL1,     { NE } , { C 'FF'    } ,  { OR   }   [,REG=]
                   { GE }   { B '01'    }    { THEN }
                   { LE }   { LABEL2    }
                            { (R2)      }
                            { NUMBER    }
```

REG = DEFAULTS TO $0

Examples:

```
      IF   B, A, IS, ZERO, THEN
+     CLI  A, X'00'
+     BC   7, LABEL
      CODE-BODY
      ENDIF
+LABEL  EQU *
```

```
      IF   B, A, EQ, BBB, THEN, REG=$1
+     IC   $1, BBB
+     STC  $1, *+5
+     CLI  A, X'00'
+     BC   7, LABEL
      CODE-BODY
      ENDIF
+LABEL  EQU *

      IF   B, A, EQ, ($1), THEN
+     STC  $1, *+5
+     CLI  A, X'00'
+     BC   7, LABEL
      CODE-BODY
      ENDIF
+LABEL  EQU *
```

These B forms of the IF statement alters executable code and are not usable if the program is to be re-entrant.

Reentrant B Type:

```
    IF  B,A,EQ,B,THEN
+   CLC 0+A,B
+   BC  7,L1

    CODE-BODY

    ENDIF
L1  DS  0H

    IF  B,B,EQ,($1),THEN
+   EX  $1,*+8
+   B   *+8
+   CLI B,0
+   BC  7,L1

    CODE-BODY

    ENDIF
L1  DS  0H
```

```
    IF  B,A,GT,X'4F',THEN
+   CLI A,X'4F'
+   BC  13,LABEL
    CODE-BODY
    ENDIF
+LABEL  EQU *
```

```
         IF       B,A,GT,138,THEN
+        CLI      A,138
+        BC       13,LABEL

         CODE-BODY

         ENDIF
+LABEL   EQU  *

         IF       B,A,GT, 0+MUD,THEN
+        CLI      A,0+MUD
+        BC       13,LABEL

         CODE-BODY

         ENDIF
+LABEL   EQU  *
           }
MUD       EQU  186
```

4. **Fixed-Point (H or F):**

```
         {H}     (R1)         {ONE(S)  }     {AND }
    IF   {F}  ,  LABEL1  , IS,{PLUS    }  ,  {OR  }   [,REG=]
                              {MINUS   }     {THEN}
                              {ZERO(S) }
                              {NZERO(S)}
                              {NMINUS  }
                              {NPLUS   }
                              {NONE(S) }

                          {GT}   {LABEL2 }
         {H}     (R1)     {LT}   {(R2)   }     {AND }
    IF   {F}  ,  LABEL1,  {GE} , {=F'   '} ,   {OR  }   [,REG=]
                          {EQ}   {=H'   '}     {THEN}
                          {NE}   {=X'   '}
                          {LE}   {=C'   '}
```

[REG=]    Defaults to $0

```
     IF   H,A,IS,PLUS,THEN
+    LH   $0,A
+    LTR  $0,$0
+    BC   13,LABEL
     BODY-CODE
     ENDIF
+LABEL  EQU  *

     IF   H,($1),IS,ZERO,THEN,REG=($1)
+    LTR  $1,$1
+    BC   7,LABEL
     BODY-CODE
     ENDIF
+LABEL  EQU  *
```

```
    IF  H,A,GT,B,THEN,REG=$5
+   LH  $5,A
+   CH  $5,B
+   BC  13,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU *

    IF  H,A,EQ,($1),THEN

+   CH  $1,A
+   BC  7,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU *

    IF  H,($1), EQ,($2),THEN,REG=($1)
+   CR  $1,$2
+   BC  7,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU *

    IF  F,A,IS,PLUS,THEN
+   L  $0, A
+   LTR  $0,$0
+   BC  13,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU *

    IF  F,($1), IS,ZERO,THEN,REG=($1)
+   LTR  $1,$1
+   BC  7,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU *
```

```
    IF  F,A,GT,B,THEN,REG=($5)
+   L  $5,A
+   C  $5,B
+   BC  13,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU  *

    IF  F, ($1),GT,B,THEN,REG=($1)
+   C  $1,B
+   BC  13,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU  *

    IF  F,A,EQ, ($1),THEN

+   C  $1,A
+   BC 7,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU  *

    IF  F, ($1),EQ, ($2),THEN,REG=($1)
+   CR  $1,$2
+   BC  7,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU  *
```

5. Floating-Point (E or D):

```
                         ┌ONE(S)  ┐
                         │PLUS    │
                         │MINUS   │
        ┌E┐     (R1)     │ZERO(S) │     ┌AND ┐
IF      │ │ , LABEL1,IS, <NZERO(S)> ,   │OR  │   [, REG=]
        └D┘              │NMINUS  │     └THEN┘
                         │NPLUS   │
                         └NONE(S) ┘
```

```
IF {E|D} , (R1) LABEL1, {GT|LT|GE|EQ|NE|LE} , {LABEL2|(R2)|=E' '|=D' '} , {AND|OR|THEN} [, REG=]

REG=      Defaults to FPRO

    IF  E,A,IS,PLUS,THEN
+   LE  FPRO,A
+   LTER  FPRO,FPRO
+   BC   13,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU  *

    IF  D,(FPRO),IS,ZERO,THEN,REG=(FPRO)
+   LTDR  FPRO,FPRO
+   BC  7,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU  *

    IF  E,A,GT,B,THEN,REG=(FPR4)
+   LE  FPR4,A
+   CE  FPR4,B
+   BC  13,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU  *

    IF  D,(FPRO),GT,B,THEN,REG=(FPRO)
+   CD  FPRO,B
+   BC  13,LABEL
    BODY-CODE
+LABEL  EQU  *
```

```
    IF  E,A,EQ,(FPR2),THEN

+   CE  FPR2,A
+   BC  7,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU  *

    IF  D,(FPRO),EQ,(FPR2),THEN,REG=(FPRO)
+   CDR  FPRO,FPR2
+   BC  7,LABEL
    BODY-CODE
    ENDIF
+LABEL  EQU  *
```

6. Type Field Omitted:

```
    IF  ,LABEL1,IS,ZERO,THEN,REG=(FPRO)
+   LE  FPRO,LABEL1
+   LTER  FPRO,FPRO
+   BC  7,LABEL2
    BODY-CODE
    ENDIF
+LABEL2    EQU  *

LABEL1  DC  E'0'
```

7. Character (C):

```
                     { LT }
                     { GT }              { AND  }
    IF   C,LABEL1,   { GE }  ,LABEL2,    { OR   }  [REG=]
                     { EQ }              { THEN }
                     { LE }
                     { NE }
```

Example:

```
    IF      C,ABLE,EQ,BETA,THEN
+   CLC     ABLE,BETA
+   BC      7,LABEL

    CODE-BODY

    ENDIF
+LABEL  EQU  *
```

8. Test Under Mask (T)

```
                                  ⎧ ZERO   ⎫
                                  ⎪ ONES   ⎪  ⎧AND ⎫
                                  ⎪ ON     ⎪  ⎨OR  ⎬
IF      T, LABEL1,   {MASK}   ,   ⎨ OFF    ⎬, ⎩THEN⎭   [,REG=]
                                  ⎪ MIXED  ⎪
                                  ⎪ NONES  ⎪
                                  ⎩ NMIXED ⎭
```

**Example:**

```
          IF    T,A,X'11',ZERO,THEN
+         TM    A,X'11'
+         BC    7,LABEL

          CODE-BODY

          ENDIF

+LABEL   EQU   *
```

PROGRAMMING NOTES

1. There can be as many as 20 nested IF statements. Each IF statement has to have a corresponding ENDIF statement.

2. The level of a nested IF statement can be found in the LABELS that are generated.

   Example:

```
    IF  condition,  THEN
+   BC    ,IF   5   0025


    ENDIF
+IF 5   0025   EQU  *
```

   The 5 stands for the level of this nested IF statement.

3. There is no limit on the number of IF-OR/IF-AND statements but after the last IF-OR/IF-AND statement there has to be an IF-THEN statement.

4. Any time a register notation is used in an IF statement the register must be in parentheses. If the parentheses are left off the IF macro would treat the register number as a label.

5. Misspelling and abbreviation of "conditions" mnemonices is not allowed.

6. The default register for fixed-point instructions is $0 and for floating-point instructions is FPRO.

7. In using the structured code macros

```
                GT
   ~~label,     LT ,  ZERO,~~
                EQ
```

   generates more inefficient code than does

   the equivalent statement using the IS opcode.

```
                         PLUS
   i.e.,   ~label, IS,   ZERO  ~~~~
                         MINUS
```

8. Reentrant programs that use the B TYPE (BYTE) IF statements should set the global flag &$RENT to 1. This flag will assure that the code generated by the IF macro is reentrant. This reentrant code is slower than the none reentrant code and should be used only in reentrant programs. The global flag has to be defined and set before a CSECT statement. See the examples of the B TYPE IF statement.

Example:

```
        GBLB  &$RENT
&$RENT  SETB  1
XXXXXX  CSECT
          }
```

NAME - MATH

DESCRIPTION

This macro can be used to save coding time when coding equations in Assembler Language, by translating an equation oriented language into Assembler Language. Basically, the MATH macro is similar to the RTFMT macro in that it translates character strings into Assembler Language instructions.

The following is an attempt to describe how MATH works and how to use it effectively.

INTRODUCTION

The MATH macro can be used to convert a "quoted-character-string", of valid "OPERANDS", separated by valid "OP-CODES", into their corresponding Assembler Language instructions. The main purpose of this macro is to let the user write a floating point equation or expression in a manner similar to that used in FORTRAN. It therefore has been designed around the floating point instruction set; though, by correct choice of options many of the fixed point instructions may be utilized.

Before considering any of MATH's advantages, disadvantages, applications, etc., certain definitions should be presented and a description given of how MATH processes an expression.

DEFINITION

OP-CODE - An OP-CODE is a special character or combination of characters which designates the operation to be performed using the following "OPERAND". In general there exist a one-to-one correspondence between each OP-CODE and some Assembler Language instruction.

All OP-CODES must be immediately preceeded and followed by atleast one blank. The following is a list of the valid OP-CODES and their correspondence machine operation:

| OP-CODE | Operation | |
|---|---|---|
| + | Add | Mathematical OP-CODES |
| PLUS | Add | |
| - | Subtract | |
| MINUS | Subtract | |
| / | Divide | |
| OVER | Divide | |
| * | Multiply | |
| TIMES | Multiply | |
| = | Store | Store OP-CODES |
| STORE | Store | |
| STORE-IN | Store | |
| SAVED-IN | Store | |
| C | Compare | Compare OP-CODES |
| WITH | Compare | |
| COMPARE | Compare | |
| TO | Compare | |
| $ | Place label on next instruction | Equate OP-CODES |
| EQU | Place label on next instruction | |
| HERE= | Place label on next instruction | |
| LABEL= | Place label on next instruction | |
| XOR | Exclusive OR | Logical OP-CODES (may only be used in fixed point mode) |
| OR | Or | |
| AND | And | |
| . | Load | Load OP-CODE |
| LOAD | Load | |
| RELOAD | Load | |

Besides the above OP-CODES there is also a set of OP-CODES which correspond to many of the extended mnemonics for branch on conditions. The list of these OP-CODES and there corresponding branch conditions are listed on the next page:

| OP-CODES | Condition | |
|---|---|---|
| B | 15 | Branch-on-condition OP-CODES |
| BH | 2 | |
| BL | 4 | |
| BE | 8 | |
| BO | 1 | |
| BP | 2 | |
| BZ | 8 | |
| BNH | 13 | |
| BNL | 11 | |
| BNE | 7 | |
| BNP | 13 | |
| BNZ | 7 | |

NUMBER - Any combination of characters which begins with a - , . , or a 0 - 9, will be placed in the corrected precision floating point literal. There may be no internal blanks in the character combinations making up the NUMBER.

Note: Further information on valid NUMBER character combination may be found under floating point constants in the Assembler Language Manual (C28-6514).

Note: NUMBERS may not be used in fixed point mode. Instead LITERALS should be used in their place. (see page 3-4 for definition of a LITERAL.)

Examples:

1, -400, .100, 1.0 E-10, .0001E5, 0.100, 0, 1.054, 100, etc.

TERM - A TERM is any combination of characters which begins with a letter (A → Z, $, @). Each TERM is assumed to be a valid Assembler Language operand. There may be no internal blanks in the character combination making up a TERM.

SYMBOL - In writing a symbol the following rules must be conformed to:

1. A symbol must consist of one to eight characters. The first character must be a letter. The other characters may be letters or digits (0 through 9).

2. No special characters or blanks are allowed in a symbol.

REG - Any combination of Characters beginning with a "(" is assumed to specify a Register (REG). The last character in this character string should be a ")". There may be no internal blanks in the character combination making up the REG. The characters between the first and last paren in the string must either be a valid register number or a symbol which has been previously equated to a register number.

Note: The macro will set up the following equates in each assembly in which it is used:

| | | | |
|---|---|---|---|
| FPR0 | EQU | 0 | These are therefore special symbols and should not be used as statement symbols in an assembly. |
| FPR2 | EQU | 2 | |
| FPR4 | EQU | 4 | |
| FPR6 | EQU | 6 | |

LITERAL - A LITERAL has the same definition here as it has in Assembler Language except that as in all character strings all quotes must be replaced by double quotes.

Examples:

| Literal as written in Assembler Language | Its Corresponding Literal In Math |
|---|---|
| =X'46000000' | =X"46000000" |
| =F'1' | =F"1" |
| =A(A-B) | =A(A-B) |

OPERAND - An OPERAND is any valid SYMBOL, TERM, LITERAL, NUMBER, REG, EXP, or PREFIXED-EXP (see definition below of EXP and PREFIXED-EXP).

EXP - An EXP expression is a combination of OPERANDs separated by the desired OP-CODES. Before the first OPERAND in each EXP must be a "(" followed immediately by at least one blank. After the last OPERAND in each EXP must by a ")", which may be preceded by as many blanks as desired.

EXP-REG - In evaluating each EXP, one register is used to contain all intermediate results such that when the last OP-CODE in the EXP has been processed this register will contain the value of the expression. This register is called the expression's register, "EXP-REG".

Example:

In FPR0 was the EXP-REG for the following EXP, FPR0 would contain a +2 when the last OP-CODE is processed.

```
(1 + 4 - 3)

LE     FPR0, =E'1'  )
AE     FPR0, =E'4'  }  Code generated by above EXP
SE     FPR0, =E'3'  )
```

PREFIXED-EXP - A PREFIXED-EXP is any EXP which is immediately preceded by a special operation prefix. This prefix will cause the corresponding special operation to be performed on the EXP-REG, of the associate EXP, immediately after the last OP-CODE in the EXP has been processed. All the special operations are register to register operations with the EXP-REG being but the first and second operand. The following is a list of the valid prefixes and the operations they cause to be performed on the EXP-REG.

| PREFIX | OPERATION |
|---|---|
| ABS | Load Positive |
| NEG | Load Negative |
| TEST | Load and Test |
| COMP | Load Compliment |
| HALF | Halve |
| DUBL | Add it to itself |
| SQAR | Multiply it times itself |

Example:

If the following EXP were encountered with the EXP-REG = FPR2, then the following code would be generated; if TYP=E

SQAR (A - B)

```
LE     FPR2,A      }
SE     FPR2,B      }  code generated by above EXP
MER    FPR2,FPR2   }
```

MAIN-EXP - The entire character-string to be converted by MATH is called the MAIN-EXP. It is just like any other EXP, except the beginning card and the ending parenthesis are replaced with single quotes.

Example:

| EXP | Corresponding MAIN-EXP |
|---|---|
| (A * (A - B + C)) | 'A * (A - B + C )' |

INNER-EXP - Any EXP contains characters which are a subset of the characters of another EXP, is an INNER-EXP with respect to this other EXP.

OUTER-EXP - An expression which contains one or more INNER-EXPs is outer to each of them.

REG-LIST - The register symbols specified in the field of the REG parameter is called the REG-LIST (see the macro definition on page 3-13).

SYSPARM-TERM - It is often necessary to reference a number stored as a system parameter in processing an equation. This may be done in the MATH macro in the following manner.

If MXXXXX is the system parameter you wish to use, code:

```
SYSPARM(MXXXXXNN)
        ↙          ↘
 System            number (optional)
 parameter
 name
```

MXXXXX = six character system parameter name.

NN = one or two digit number to be used as a displacement of the system parameter in referencing it. This will probably only be needed when referencing a system parameter which is an array such as MHRSYT.

Note: As in all TERMS, there may be no imbedded blanks.

Note: In picking up the address of the system parameter, register 1 will be used.

Examples:

```
MATH     'A * SYSPARM(MCRFMN)', TYP=E
              ↓ code generated
          LE  FPRO, A
          L   1, =V(MCRFMN)
          ME  FPRO, 0(1)

MATH     'A * SYSPARM(MHRSYT8)', TYP=E
              ↓ code generated
          LE  FPRO, A
          L   1, =V(MHRSYT)
          ME  FPRO, 8(1)
```

For more examples, see pages

## SPECIAL CAPABILITIES

A special capability exists which lets any valid Assembler Language instruction, which does not contain any quotes, be coded as a Math OP-CODE and OPERAND. This is accomplished by coding a # sign immediately before the Assembler Language mnemonic, skipping at least one blank after the mnemonic, and then coding the OPERAND exactly as it would in the Assembler Language instruction.

Examples:

| MATH OPCODE | MATH OPERAND | | ASSEMBLY LANGUAGE STATEMENT GENERATED |
|---|---|---|---|
| #ST | 3, XYZ | ⟶ | ST 3, XYZ |
| #TM | 0 (4), 1 | ⟶ | TM 0(4), 1 |
| #SLL | 3, 0 (4) | ⟶ | SLL 3, 0(4) |
| #ST | ONE, A + 3(5) | ⟶ | ST ONE, A + 3(5) |

Note: This capability lets the user embed special operations within the code generated by the macro without having to break the equation up into several parts.

The ability also exists to raise a floating point number to a floating point power via the MATH Macro. This greatly simplifies the coding needed to accomplish this use of the FRXPR# and FDXPD# "power" routines. Also if the "power" routine must be used more than once per assembly, space will be saved by using MATH rather than the CALL Macro because MATH uses the same argument list each time.

Note: The "power" routine will use all four floating point registers. Therefore, it is not possible to save values in these registers across any MATH expansion in which the "power" facility is used. Also since these registers are used by the "power" routine, the power OP-CODE may not be used except in the MAIN-EXP.

To use this facility one need only use the "**" symbol within the MAIN-EXP. This will cause the value currently contained by this Expression's EXP-REG to be raised to the power stated by the OPERAND immediately following the ** symbol. (See the following examples).

Examples:

The following are examples of a few of the possible uses of the power OP-CODE and the Assembler Language code which will be generated in each case.

```
59            MATH   '  A  **  B  =  A+16'

61+FPR0       EQU    0                  ***
62+FPR2       EQU    2                     ***   SET UP EQUATES FOR THE
63+FPR4       EQU    4                     ***    FLOATING POINT REGS
64+FPR6       EQU    6                  ***

67+           LE     FPR0,A                    A SYMBOL
68+           B      *+36                      BRANCH PAST PARM LIST
69+PARG0001   DC     D'0'                      FIRST ARG TO POWER ROUTINE
70+PARG0002   DC     D'0'                      SECND ARG TO POWER ROUTINE
71+APARG001   DC     A(PARG0001),X'80',AL3(PARG0002) POWER ARG LIST
72+SVFPR0XX   DC     D'0'                     WHERE PWR SAVES FPR0
73+           STE    FPR0,PARG0001                    1ST  ARG  TO POWER
74+           LE     FPR0,B                    A SYMBOL
75+           STE    FPR0,PARG0002                    2ND ARG TO POWER
76+           L      15,=V(FRXPR=)               A( REAL*4 POWER ROUTINE )
77+           LA     1,APARG001               A( ARGUMENT LIST )
78+           BALR   14,15        FPR0 = ARG1 ** ARG2
79+           STE    FPR0,A+16                    A SYMBOL
80                   *,--- REG = FPR0 WAS USED IN EVALUATING THE EQUATION
81+*                                                                              *
82+*                                                                              *
83+***** END ***** OF ***** EQUATION ***************************************
```

```
350     MATH  '( A + 1 ) / B  ** ( ( B + 1 ) / A )  = C',TYP=D

352+          LD     FPR0,A                  A SYMBOL
353+          AD     FPR0,=D'1'                  NUMBER TYPE
354+          DD     FPR0,B                  A SYMBOL
355+          STD    FPR0,PARG0001                  1ST  ARG  TO POWER
356+          LD     FPR0,B                  A SYMBOL
357+          AD     FPR0,=D'1'                  NUMBER TYPE
358+          DD     FPR0,A                  A SYMBOL
359+          STD    FPR0,PARG0002                  2ND ARG TO POWER
360+          L      15,=V(FDXPD=)            A( DOUBLE PRE  POWER ROUTINE )
361+          LA     1,APARG001             A( ARGUMENT LIST )
362+          BALR   14,15          FPR0 = ARG1 ** ARG2
363+          STD    FPR0,C                  A SYMBOL
364                  *,--- REG = FPR0 WAS USED IN EVALUATING THE EQUATION
365+*                                                                          *
366+*                                                                          *
367+***** END ***** OF ***** EQUATION *****************************************


199           MATH  '( A + 4.0 )   **   ( B  *  .518 )  =  C  ',TYP=D

201+          LD     FPR0,A                  A SYMBOL
202+          AD     FPR0,=D'4.0'                  NUMBER TYPE
203+          STD    FPR0,PARG0001                  1ST  ARG  TO POWER
204+          LD     FPR0,B                  A SYMBOL
205+          MD     FPR0,=D'.518'                  NUMBER TYPE
206+          STD    FPR0,PARG0002                  2ND ARG TO POWER
207+          L      15,=V(FDXPD=)            A( DOUBLE PRE  POWER ROUTINE
208+          LA     1,APARG001             A( ARGUMENT LIST )
209+          BALR   14,15          FPR0 = ARG1 ** ARG2
210+          STD    FPR0,C                  A SYMBOL
211                  *,--- REG = FPR0 WAS USED IN EVALUATING THE EQUATION
212+*                                                                          *
213+*                                                                          *
214+***** END ***** OF ***** EQUATION *****************************************


216           MATH  '( A + 4.0 )   **   ( B  *  .518 )  =  C  '

218+          LE     FPR0,A                  A SYMBOL
219+          AE     FPR0,=E'4.0'                  NUMBER TYPE
220+          STE    FPR0,PARG0001                  1ST  ARG  TO POWER
221+          LE     FPR0,B                  A SYMBOL
222+          ME     FPR0,=E'.518'                  NUMBER TYPE
223+          STE    FPR0,PARG0002                  2ND ARG TO POWER
224+          L      15,=V(FRXPR=)            A( REAL*4 POWER ROUTINE )
225+          LA     1,APARG001             A( ARGUMENT LIST )
226+          BALR   14,15          FPR0 = ARG1 ** ARG2
227+          STE    FPR0,C                  A SYMBOL
228                  *,--- REG = FPR0 WAS USED IN EVALUATING THE EQUATION
229+*                                                                          *
230+*                                                                          *
231+***** END ***** OF ***** EQUATION ************************
```

## RULES MATH USES IN PROCESSING AN EXPRESSION

1. All processing is performed left to right.

2. Each time an INNER-EXP is encountered, the following steps take place:

   a. An EXP-REG is determined for this INNER-EXP.

   b. The INNER-EXP is evaluated in this EXP-REG.

   c. Any special operation, specified by a prefix on the INNER-EXP, is performed on its EXP-REG.

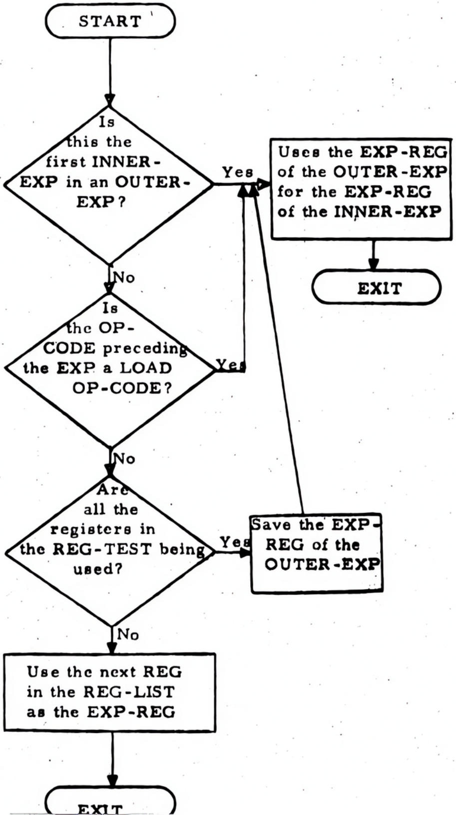
   d. The EXP-REG is used as the operand for the OP-CODE preceding the INNER-EXP.

3. The first OPERAND in each expression is loaded into its EXP-REG unless the first operand is a REG which has the same character structure as the EXP-REG.

   Example: If, in the following expression, the macro was specified as:

   ```
   MATH ' (4) + A * ( (FPR2) + (6) )', REG = (4, FPR2), TYP=D
          |
          | code generated
          v
          AD    4,A
          ADR   FPR2,6
          MDR   4,FPR2
   ```

4. In determining which register will be the EXP-REG for an expression, it follows the procedure below:


START
Is this the first INNER-EXP in an OUTER-EXP?
Yes
Uses the EXP-REG of the OUTER-EXP for the EXP-REG of the INNER-EXP
EXIT
No
Is the OP-CODE preceding the EXP a LOAD OP-CODE?
Yes
No
Are all the registers in the REG-TEST being used?
Yes
Save the EXP-REG of the OUTER-EXP
No
Use the next REG in the REG-LIST as the EXP-REG
EXIT

5. The character from the TYP parameter (see the macro definition below) is used in forming all instructions.

Example: If, in the following EXP, the EXP-REG was 0, then the following code would be generated for each TYP.

EXP = ( A * B = C )

```
TYP = E:    LE     0,A
            ME     0,B
            STE    0,C

TYP = H:    LH     0,A
            MH     0,B
            STH    0,C

TYP =       L      0,A
            M      0,B
            ST     0,C
```

MATH MACRO DEFINITION

| | | |
|---|---|---|
| [Symbol] | MATH | MAIN-EXP [, REG=register list]<br>[, TRACE=ON or OFF]<br>[, ANS = where to put answer]<br>[TYP=character or null] |

[ ] - optional

MAIN-EXP - as described on page 3-6. There may be a maximum of 255 characters in a MAIN-EXP.

TYP - the type of instruction to be generated. (The character to be in each instructions, i.e., E, D, H, null, etc.) Default is TYP = E.

TRACE - On causes the expression and its EXP-REG to be printed when the last OP-CODE in the EXP has been processed. Default is TRACE=OFF. These intermediate expressions can sometimes make following the generated code much easier.

ANS - any valid SYMBOL or REG.

Default is to leave the answer in the first register specified in the REG-LIST.

REG - a single register label or number, or a sublist of one or more register labels or numbers.

Default: REG = (FPRO, FPR2, FPR4, FPR6)

NOTE: The registers specified in this REG-LIST tell the MATH macro which registers it can use to do the calculations in, and what order to use the registers in as it needs new EXP-REGs.

PROGRAMMING NOTES

1. All Equate and Branch OP-CODES must be followed by a valid SYMBOL.
2. The Equate OP-CODE causes the SYMBOL following the OP-CODE to be equated to the address of the next instruction.
3. The Branch-on-condition OP-CODE causes an immediate generation of the same branch on condition to the SYMBOL following the OP-CODE.
4. The HALF and SQAR prefix is invalid in the fixed point mode.
5. The multiply and divide OP-CODES are not valid in the fullword fixed point mode.
6. The XOR, AND, and OR OP-CODES are invalid in the floating point mode.
7. The Divide OP-CODE is invalid in all fixed point modes.

8. Whenever a STORE-OP-CODE appears in an EXP, the value currently in the EXP-REG is stored in the TERM following the OP-CODE for later use in the program.

9. Whenever a LOAD-OP-CODE appears in an EX, it causes the EXP-REG to be loaded with the next OPERAND in the EXP.

10. It should be noted that the hierarchy of operations which exist in fortran does not exist in MATH.

    Example:

    Fortran instruction: C = A - B / D
    MATH equivalent: 'A - (B / D) = C'
    or COMP (B / B) + A = C'

11. Since MATH is only an interpreter and not a compiler, it can only do what it is told in the same order it is told to do it. Therefore, if proper care is taken in arranging the operations in a floating point MATH expression, the floating point operations generated will be as tight as can be generated by coding each instruction separately. The following is an example of how to code tighter in MATH. Both of the following MATH expressions will do the same thing except the second expression requires one register instead of two like the first, and the second expression requires one less instruction.

    Example 1: MATH ' C * (A + B) = D'
    Example 2: MATH ' A + B * C = D'

12. The MATH macro may need storage space whenever it runs out of registers and encounters another level of INNER-EXP. For this reason, MATH will set up, and keep track of, any save areas it needs. There will be special labels on these save areas as follows:

    FRSAVE0N N = 1 ⟶ 9 and MATHTSVR

    These labels should not be used in any assembly in which the MATH Macro is used.

13. Though I have tried to list most of the major uses and limitations of MATH, I am sure there still exist several other possible uses and probably still more limitations. However, once the basic mechanics of MATH are fully understood, both its faults and attributes should become almost obvious.

14. MATH will perform special error checking for conditions not checked by the assembler. When it encounters one of the errors, it will flag it with a MNOTE statement having a condition code of 12.

15. The Branch-on condition OP-CODES will accept any combination of eight or less characters as a valid address and let the assembler perform the error checking on them.

EXAMPLES

The following is an example of an expansion of the MATHSAVE macro: of MATH's OP-CODES and OPERANDS.

```
TEST1    MATH  ' A * B / (2) + A+4 - 99'
  MATH  ' DUBL( A) - B'
TEST3    MATH  ' A+8 * B(5)',ANS=(FPR6)
TEST4    MATH  ' A+4 / B',ANS=B+8($5)
TEST5    MATH  ' A * ( B - A * ( A+8 - B ) )'
TEST6    MATH  ' A * ( B - A * ( A+8 - 10))',REG=2
TEST7    MATH  ' (2) / (4) * (6) + .01 - A(5)',REG=0,ANS=B,TRACE=OFF
TEST8    MATH  '    A     * ( 1 +  A  * ( 1 + A  *   ( 1 + A *       X
               ( 1    +  A ))))',ANS=B,TRACE=OFF,TYP=D
TEST9    MATH  '  A  - ( A + B - A+8($5)    *  .0199E-24 )',ANS=(FPR6)
TEST10   MATH  ' ABS( A - B) - 1.99'
TEST11   MATH  ' A - ABS( A - B + (2) )'
         MATH  ' NEG( A - B PLUS (2) ) PLUS A',TRACE=OFF,TYP=
TEST12   MATH  '        A  +  ABS(  A - ABS( A - B))'
         MATH  'ABS( NEG( A MINUS B) + A) PLUS A'
TEST13   MATH  ' A / ABS( A - B  ) + ABS( ( B - 100 ) / ( A - .99
                 ))',REG=4,ANS=B
TEST14   MATH  'A +    ABS(   A   -  B  -   100)      +
               (   A  *  A  *  A * A * A)',REG=6
         MATH  'SQAR( SQAR( A)) TIMES A + ABS( A - B - 100) + A',REG=6
```

```
TESTALL  MATH  '1 + ABS( A / B )  +                                 X
                 ABS( ( A - B) - ( A+4 - B+4) )    /                X
                 ABS( ( A+16 - B+16 ) -  ( A+20 - B+20 ))',         X
               REG=(2,6),ANS=A+4

         MATH  '1 + ABS( A / B )  +                                 X
                 ABS( ( A - B) - ( A+4 - B+4) )    /                X
                 ABS( ( A+16 - B+16 ) -  ( A+20 - B+20 ))',         X
               REG=3,ANS=A+4,TYP=D,TRACE=OFF

         MATH  ' ABS( ABS( A - B) - A)'

         MATH  ' NEG( A - B)'

         MATH  ' DUBL( A - B)'

         MATH  ' SQAR( A - B)'

         MATH  ' COMP( A - B)'

         MATH  ' HALF( A)'



         MATH  ' COMP( A)'

         MATH  ' DUBL( A)'

         MATH  'SYSPARM(MCRFMN) - 12 WITH A BNE ZERO * SYSPARM(MCCFCU) X
                 STORE B+8       ',TYP=D,TRACE=OFF,REG=FPR6

         MATH  'A / ( TEST( A - 100) BZ ZERO) * ( A - B) BZ ZERO'

    MATH 'A MINUS B($5) TIMES 100 OVER -400  PLUS (2) HERE= BP200   X
               BM ZERO LABEL= BP201 BZ ZERO STORE B+B LOAD A - B = B'

         MATH  '  ABS(  A - ( ABS( A - B) - A       ) - B )  ',REG=6

         MATH  ' ABS( NEG( DUBL( A)) / COMP( HALF( B)) * SQAR( A))'

         MATH  ' ( (4) / (6) - (2)) - A + 10      ',REG=0

         MATH  '( A + B) C ( A - 299 ) BP POSITIVE BZ ZERO * -400'

         MATH  ' ( ( ( ( A + B  )))) - B+4'

         MATH  ' ( ( ( (4) ) ) )'

         MATH  'TEST( A - B($5)  * 100  / -400  * (2) )
```

```
TESTER    MATH  '   A+B +  SQAR( A - B )  - SQAR( HALF( HALF( (6))))     X
                 -  ABS(  A *  (FPR6)  ) + ( ( A - B) / B(5) / -1000   X
                * ( A+16(5) - DUBL( A - .001)  +  ABS( A -   .1E-10) ) *X
                 COMP( DUBL(  A * B) - (FPR2))           EQU BP300    /   X
                NEG( HALF( SQAR( B * 9.5 ))))',REG=FPR4,ANS=(FPR4),      X
                TYP=D,TRACE=OFF

TESTER2   MATH  '   A+B +  SQAR( A - B )  - SQAR( HALF( HALF( (6))))     X
                 -  ABS(  A *  (FPR6)  ) + ( ( A - B) / B(5) / -1000   X
                * ( A+16(5) - DUBL( A - .001)  +  ABS( A -   .1E-10) ) *X
                 COMP( DUBL(  A * B) - (FPR2))           EQU BP301    /   X
                NEG( HALF( SQAR( B * 9.5 ))))',REG=(FPR4,FPR6),          X
                TYP=D,TRACE=OFF,ANS=(FPR4)

  MATH ' SQAR( SQAR( SQAR( SQAR( SQAR( SQAR( SQAR( B))))))))'   = B**128

          MATH  '( A * B = B+4 * B+8 = B+16 * B+20) C 100               X
                BH POSITIVE BE ZERO = B+24'


          MATH  '( A * B = B+4 * B+8 = B+16 * B+20) WITH 100            X
                BH POSITIVE BE ZERO = B+24',TRACE=OFF,TYP=H,REG=7

  MATH ' A PLUS B MINUS 100 OVER (2)  STORE B+4 TIMES SYSPARM(MCRFMNB)'

          MATH  ' SYSPARM(MKTYPE) ',REG=5,TYP=H

          MATH  'A / ( A+4 - 0.001 BNP ZERO .   10 * A)'

          MATH  '   A  * SYSPARM(MCRFMN) / SYSPARM(MHRSYT04)'

          MATH  '  A * SYSPARM(MCRFMN)   = B',TYP=D

          MATH  '  SYSPARM(MHRSYT16) STORE  A',TYP=,REG=5

          MATH  '  SQAR( SYSPARM(MCRFMN)) = A',TYP=D

          MATH  '  SQAR( SYSPARM(MCRFMN)) STORE A',TYP=D

          MATH  ' A - B BP BP1 . 100 EQU BP1 * ( A - SQAR( A)) = B+4'

          MATH 'A C 5 BE ZERO C 10 BE POSITIVE C 15 BE ZERO              X
                 C 20 BL   ZERO   = B LOAD 100 STORE B',TRACE=OFF

          MATH  ' TEST( A ) BZ ZERO C (3)  BE POSITIVE + B  = B',TYP=,   X
                REG=7
```

```
      MATH  'A + A+4 + A+8 + A+12 + A+16 = B',TYP=,REG=5

MATH  ' SYSPARM(MGJBAT) LOAD  $0+16(3)  STORE-IN B',TYP=,REG=3

      MATH  ' A   HERE= ASDFASDF * ( A - B)'

      MATH  ' A    $    GHJKFGHJ * ( A - B)'

      MATH  ' A TO B BE ZERO'

      MATH  ' A COMPARE B BNE ZERO'

      MATH  ' A COMPARE B BNE ZERO',TYP=D

      MATH  ' A COMPARE B BNE ZERO',TYP=

      MATH  '  A - B BNM BP8 - B    LABEL= BP8 * (  A * B)'

      MATH  'A WITH B BNE NOTEQ = B B ZERO LABEL= NOTEQ LOAD =F''100X
            '' STORE B B ZERO',TYP=,TRACE=OFF

      MATH  ' A AND B BZ ZERO OR ( A + B)  XOR =X''0F0F0F0F''      X
             SAVED-IN B+4  WITH A BE ZERO OR (3)  XOR (5)  = B ',   X
            REG=(7,9),TRACE=OFF,TYP=

      MATH  ' (FPR0) * (2) OVER ( (4) - A)',REG=(FPR0,4)
```

The following examples are expansions of some of the above MATH expressions:

```
            MATH  'A / ( A+4 - 0.001 BNP ZERO .   10 * A)'

            LE    FPR0,A                 A SYMBOL
            LE    FPR2,A+4                 A SYMBOL
            SE    FPR2,=E'0.001'                NUMBER TYPE
            BNP   ZERO                 BRANCH ON CONDITION
            LE    FPR2,=E'10'                NUMBER TYPE
            ME    FPR2,A                 A SYMBOL
                  *,----------- REG = FPR2     NOW CONTAINS -------------*X
                   ' A+4 - 0.001 BNP ZERO .    10 * A'
                  *---------------------------------------------------------*
            DER   FPR0,FPR2
                  *,----------- REG = FPR0     NOW CONTAINS -------------*X
                   'A / ( A+4 - 0.001 BNP ZERO .    10 * A)'
                  *---------------------------------------------------------*
                  *,--- REG = FPR0 WAS USED IN EVALUATING THE EQUATION
                  *,--- REG = FPR2 WAS USED IN EVALUATING THE EQUATION
                                                                            *
                                                                            *
****** END ***** OF ***** EQUATION *****************************************
```

```
1229            MATH   ' SYSPARM(MKTYPE) ',REG=5,TYP=H

1231+           L      1,=V(MKTYPE)          LOAD REG1 WITH ADDR OF SYSPARAM
1232+           LH     5,0(1)            OP USING VALUE OF SYSPARM
1233                   *,----------- REG = 5          NOW CONTAINS -------------*X
                        ' SYSPARM(MKTYPE) '
1234+*                 *--------------------------------------------------------*
1235                   *,--- REG = 5 WAS USED IN EVALUATING THE EQUATION
1236+*                                                                          *
1237+*                                                                          *
1238+***** END ***** OF ***** EQUATION *****************************************


1628            MATH   ' A AND B BZ ZERO OR ( A + B)  XOR =X''0F0F0F0F''
                        SAVED-IN B+4  WITH A BE ZERO OR (3)  XOR (5)  = B ',
                       REG=(7,9),TRACE=OFF,TYP=

1630+           L      7,A                   A SYMBOL
1631+           N      7,B                   A SYMBOL
1632+           BZ     ZERO                   BRANCH ON CONDITION
1633+           L      9,A                   A SYMBOL
1634+           A      9,B                   A SYMBOL
1635+           OR     7,9
1636+           X      7,=X'0F0F0F0F'                   A SYMBOL
1637+           ST     7,B+4                  A SYMBOL
1638+           C      7,A                   A SYMBOL
1639+           BE     ZERO                   BRANCH ON CONDITION
1640+           OR     7,3                     A REG TYPE
1641+           XR     7,5                     A REG TYPE
1642+           ST     7,B                   A SYMBOL
1643                   *,--- REG = 7 WAS USED IN EVALUATING THE EQUATION
1644                   *,--- REG = 9 WAS USED IN EVALUATING THE EQUATION
1645+*                                                                          *
1646+*                                                                          *
1647+***** END ***** OF ***** EQUATION *****************************************
```

```
60 TEST1     MATH  ' A * B / (2) + A+4 - 99'                                   0(

62+FPR0      EQU   0                 ***
63+FPR2      EQU   2                   ***   SET UP EQUATES FOR THE
64+FPR4      EQU   4                   ***    FLOATING POINT REGS
65+FPR6      EQU   6                 ***

67+TEST1     EQU   *

69+          LE    FPR0,A                  A SYMBOL
70+          ME    FPR0,B                  A SYMBOL
71+          DER   FPR0,2                    A REG TYPE
72+          AE    FPR0,A+4                A SYMBOL
73+          SE    FPR0,=E'99'                NUMBER TYPE
74                 *,----------- REG = FPR0     NOW CONTAINS -------------*X
                    ' A * B / (2) + A+4 - 99'
75+*               *-------------------------------------------------------*
76                 *,--- REG = FPR0 WAS USED IN EVALUATING THE EQUATION
77+*                                                                       *
78+*                                                                       *
79+****** END ***** OF ***** EQUATION ************************************
```

```
1260          MATH  '    A   * SYSPARM(MCRFMN) / SYSPARM(MHRSYT04)              0

1262+         LE    FPR0,A                 A SYMBOL
1263+         L     1,=V(MCRFMN)            LOAD REG1 WITH ADDR OF SYSPARAM
1264+         ME    FPR0,0(1)               OP USING VALUE OF SYSPARM
1265+         L     1,=V(MHRSYT)            LOAD REG1 WITH ADDR OF SYSPARAM
1266+         DE    FPR0,04(1)               OP USING VALUE OF SYSPARM
1267                *,----------- REG = FPR0     NOW CONTAINS -------------*X
                     '    A   * SYSPARM(MCRFMN) / SYSPARM(MHRSYT04)'
1268+*              *-------------------------------------------------------*
1269                *,--- REG = FPR0 WAS USED IN EVALUATING THE EQUATION
1270+*                                                                      *
1271+*                                                                      *
1272+****** END ***** OF ***** EQUATION ***********************************
```

```
857              MATH  ' ABS( NEG( DUBL( A)) / COMP( HALF( B)) * SQAR( A))'        0

859+             LE    FPRO,A                 A SYMBOL
860                    *,----------- REG = FPRO      NOW CONTAINS --------------*X
                         ' A'
861+*                  *---------------------------------------------------------*
862+             AER   FPRO,FPRC              SPECIAL OPERATION
863                    *,----------- REG = FPRO      NOW CONTAINS --------------*X
                         ' DUBL( A)'
864+*                  *---------------------------------------------------------*
865+             LNER  FPRO,FPRO              SPECIAL OPERATION
866+             LE    FPR2,B                 A SYMBOL
867                    *,----------- REG = FPR2      NOW CONTAINS --------------*X
                         ' B'
868+*                  *---------------------------------------------------------*
869+             HER   FPR2,FPR2              SPECIAL OPERATION
870                    *,----------- REG = FPR2      NOW CONTAINS --------------*X
                         ' HALF( B)'
871+*                  *---------------------------------------------------------*
872+             LCER  FPR2,FPR2              SPECIAL OPERATION
873+             DER   FPRO,FPR2
874+             LE    FPR2,A                 A SYMBOL
875                    *,----------- REG = FPR2      NOW CONTAINS --------------*X
                         ' A'
876+*                  *---------------------------------------------------------*
877+             MER   FPR2,FPR2              SPECIAL OPERATION
878+             MER   FPRO,FPR2
879                    *,----------- REG = FPRO      NOW CONTAINS --------------*X
                         ' NEG( DUBL( A)) / COMP( HALF( B)) * SQAR( A)'
880+*                  *---------------------------------------------------------*
881+             LPER  FPRO,FPRO              SPECIAL OPERATION
882                    *,----------- REG = FPRO      NOW CONTAINS --------------*X
                         ' ABS( NEG( DUBL( A)) / COMP( HALF( B)) * SQAR( A))'
883+*                  *---------------------------------------------------------*
884                    *,--- REG = FPRO WAS USED IN EVALUATING THE EQUATION
885                    *,--- REG = FPR2 WAS USED IN EVALUATING THE EQUATION
886+*                                                                            *
887+*                                                                            *
888+***** END ***** OF ***** EQUATION ******************************************
```

```
1435            MATH   'A + A+4 + A+8 + A+12 + A+16 = B',TYP=,REG=5                 0

1437+           L      5,A                A SYMBOL
1438+           A      5,A+4                A SYMBOL
1439+           A      5,A+8                A SYMBOL
1440+           A      5,A+12                A SYMBOL
1441+           A      5,A+16                A SYMBOL
1442+           ST     5,B                A SYMBOL
1443                   *,----------- REG = 5        NOW CONTAINS -------------*X
                        'A + A+4 + A+8 + A+12 + A+16 = B'
1444+*                 *------------------------------------------------------*
1445                   *,--- REG = 5 WAS USED IN EVALUATING THE EQUATION
1446+*                                                                        *
1447+*                                                                        *
1448+***** END ***** OF ***** EQUATION ************************************
```

```
1213   MATH ' A PLUS B MINUS 100 OVER (2)  STORE B+4 TIMES SYSPARM(MCRFMN8)' C

1215+           LE     FPR0,A                    A SYMBOL
1216+           AE     FPR0,B                    A SYMBOL
1217+           SE     FPR0,=E'100'                 NUMBER TYPE
1218+           DER    FPR0,2                      A REG TYPE
1219+           STE    FPR0,B+4                 A SYMBOL
1220+           L      1,=V(MCRFMN)             LOAD REG1 WITH ADDR OF SYSPARAM
1221+           ME     FPR0,8(1)                OP USING VALUE OF SYSPARM
1222                   *,----------- REG = FPR0     NOW CONTAINS -------------*X
                        ' A PLUS B MINUS 100 OVER (2)  STORE B+4 TIMES SYSPARM(X
                       MCRFMN8)'
1223+*                 *------------------------------------------------------*
1224                   *,--- REG = FPR0 WAS USED IN EVALUATING THE EQUATION
1225+*                                                                        *
1226+*                                                                        *
1227+***** END ***** OF ***** EQUATION ************************************
```

```
445 TESTALL  MATH  '1 + ABS( A / B )  +                                          XC
                     ABS( ( A - B) - ( A+4 - B+4) )    /                         XC
                     ABS( ( A+16 - B+16 ) -  ( A+20 - B+20 ))',                  XC
                   REG=(2,6),ANS=A+4                                              C
446+TESTALL  EQU   *
448+         LE    2,=E'1'                 NUMBER TYPE
449+         LE    6,A                   A SYMBOL
450+         DE    6,B                   A SYMBOL
451                *,----------- REG = 6         NOW CONTAINS -------------*X
                    ' A / B '
452+*              *-----------------------------------------------------*
453+         LPER  6,6                SPECIAL OPERATION
454+         AER   2,6
455+         LE    6,A                   A SYMBOL
456+         SE    6,B                   A SYMBOL
457                *,----------- REG = 6         NOW CONTAINS -------------*X
                    ' A - B'
458+*              *-----------------------------------------------------*
459+         STE   6,FRSAVE01          SAVE REGS CONTENTS
460+         LE    6,A+4                   A SYMBOL
461+         SE    6,B+4                   A SYMBOL
462                *,----------- REG = 6         NOW CONTAINS -------------*X
                    ' A+4 - B+4'
463+*              *-----------------------------------------------------*
464+         STE   6,MATHTSVR             SPECIAL SAVE FOR NON-COMMUTE OPS
465+         LE    6,FRSAVE01              RETRIEVE SAVED DATA
466+         SE    6,MATHTSVR               PERFORM OPERATION
467                *,----------- REG = 6         NOW CONTAINS -------------*X
                    ' ( A - B) - ( A+4 - B+4) '
468+*              *-----------------------------------------------------*
469+         LPER  6,6                SPECIAL OPERATION
470+         AER   2,6
471+         LE    6,A+16                    A SYMBOL
472+         SE    6,B+16                    A SYMBOL
473                *,----------- REG = 6         NOW CONTAINS -------------*X
                    ' A+16 - B+16 '
474+*              *-----------------------------------------------------*
475+         STE   6,FRSAVE01          SAVE REGS CONTENTS
476+         LE    6,A+20                    A SYMBOL
477+         SE    6,B+20                    A SYMBOL
478                *,----------- REG = 6         NOW CONTAINS -------------*X
                    ' A+20 - B+20 '
479+*              *-----------------------------------------------------*
480+         STE   6,MATHTSVR             SPECIAL SAVE FOR NON-COMMUTE OPS
481+         LE    6,FRSAVE01              RETRIEVE SAVED DATA
482+         SE    6,MATHTSVR               PERFORM OPERATION
483                *,----------- REG = 6.        NOW CONTAINS -------------*X
                    ' ( A+16 - B+16 ) -  ( A+20 - B+20 )'
484+*              *-----------------------------------------------------*
485+         LPER  6,6                SPECIAL OPERATION
486+         DER   2,6
487                *,----------- REG = 2         NOW CONTAINS -------------*X
                   '1 + ABS( A / B )  +                                       X
                                                                              X
```

CONCLUSION

The number of possible combinations of options, OPERANDS, and OP-CODES is too large to discuss each one, even briefly. Therefore, as in learning any new language, probably the best way to learn how to write expressions is to use the definition and examples as a guide in coding up a few test cases.

## MATH REFERENCE INFORMATION

| OP-CODE | OPERATION | OP-CODE | OPERATION |
|---|---|---|---|
| +, PLUS | ADD | C, WITH | COMPARE |
| -, MINUS | SUBTRACT | TO, COMPARE | COMPARE |
| /, OVER | DIVIDE | | |
| *, TIMES | MULTIPLY | ., LOAD | LOAD |
| ** | POWER ROUTINE | RELOAD | LOAD |
| =, SAVED-IN | STORE | | |
| STORE, STORE-IN | STORE | XOR | Exclusive OR |
| OR | OR | AND | AND |

| OP-CODE | OPERATION |
|---|---|
| $, HERE= | Place label on next instruction |
| EQU, LABEL= | Place label on next instruction |
| B | Branch on Condition 15 |
| BH, BP | Branch on Condition 2 |
| BL, BM | Branch on Condition 4 |
| BE, BZ | Branch on Condition 8 |
| BO | Branch on Condition 1 |
| BNH, BNP | Branch on Condition 13 |
| BNL, BNM | Branch on Condition 11 |
| BNE, BNZ | Branch on Condition 7 |

## VALID OPERAND

Any valid SYMBOL
Any valid LITERAL
Any valid REG
Any valid PREFIXED-EXP.
Any valid TERM
Any valid NUMBER
Any valid EXP

| OPERAND | STARTING CHARACTERS |
|---|---|
| NUMBERS | . , - , 0 ⟶ 9 |
| SYMBOL | A ⟶ Z, $ , and @<br>(only 8 characters at maximum) |
| TERM | A ⟶ Z, $ , and @<br>(any assembly language operand) |
| REG | "(" followed immediately by a symbol or number |
| EXP | "(" followed by at least one blank |
| LITERAL | = sign (like in assembly language except<br>quote doubled) |

VALID PREFIXES FOR EXP'S

| | |
|---|---|
| ABS | HALF |
| NEG | DUBL |
| TEST | SQAR |
| COMP | |

SPECIAL TERM FOR SYSTEM PARAMETERS

SYSPARM (MXXXXXNN)
MXXXXX = SYSPARM NAME
NN = null or 0 —— 99

NAME - NIBIT

DESCRIPTION

The function of the NIBIT macro is to generate an AND IMMEDIATE instruction which utilizes the length code of the symbol specified to "turn off" a desired bit in a byte.

DEFINITION

| | | |
|---|---|---|
| [symbol] | NIBIT | Symbol |

where Symbol is the label of a data base definition which has an associated length code.

EXPANSION

| NAME | OPERATION | OPERAND |
|---|---|---|
| [symbol] | NIBIT | LABEL |
| +[symbol] | NI | LABEL, X'FF'-L'LABEL |

GENERAL NOTES

- The NIBIT macro will be utilized most often in conjunction with the B IT macro, since BIT generates a desired length code associated with a valid label.

NAME - OIBIT

DESCRIPTION

(See XIBIT)

NAME - BIT

DESCRIPTION

The purpose of the BIT macro is to generate a data base definition whose length can be used as a key to test or manipulate a specific bit in a byte.

DEFINITION

| | | |
|---|---|---|
| symbol | BIT | {Bit number, or list of bit numbers, or binary 8-bit configuration} [,ON] |

where

- symbol -- any valid non-blank label. If omitted, an error condition will be raised with a condition code of 12.
- bit number -- an unsigned decimal integer, 0 through 7, representing standard bit notation.
- list of bit numbers -- a list of bit numbers separated by commas. The entire list must be enclosed by parenthesis.
- binary 8-bit configuration -- notation of the form B'XXXXXXXX', where X is 1 if the corresponding bit is to be represented by this label and X is 0 if the corresponding bit is not to be represented by this label.
- ON -- indicates the bit or bits indicated in the first operand are to set to 1 in a global variable which is passed to the BYTE macro.

FUNCTION

The BIT macro performs its operations as follows:

- checks to see if there is a valid non-blank label attached to the macro.
- processes the information passed by the first operand, checking each time for an invalid bit number or binary character.
- generates a DS and ORG statement to establish a length which can be used to test or manipulate bit(s), and reset the location counter setting. (There is an exception to this -- if the name of the CSECT currently being processed starts with SCDB, the DS and ORG statement will not be generated.

EXAMPLES OF THE USE

The following are included to give the user a feeling of what can and cannot be done with the BIT macro:

Example 1

| NAME | OPERATION | OPERANDS |
|---|---|---|
| FIRST | BIT | 0 |
| +FIRST | DS | XL(B'10000000') |
| + | ORG | *-B'10000000' |

Example 2

| NAME | OPERATION | OPERANDS |
|---|---|---|
| SECOND | BIT | (0, 1, 5, 7), ON |
| +SECOND | DS | XL(B'11000101') |
| + | ORG | *-B'11000101' |

Note: In the above example, specifying 'ON' had no effect upon the expansion of the macro.

NAME - ORELSE

DESCRIPTION

The function of the ORELSE macro is to generate the branch and labels that correspond with the branch instructions generated by the EXITIF macro and the labels generated by the ENDLOOP macro. See the STRTSRCH macro.

NAME - STRTSRCH

DESCRIPTION

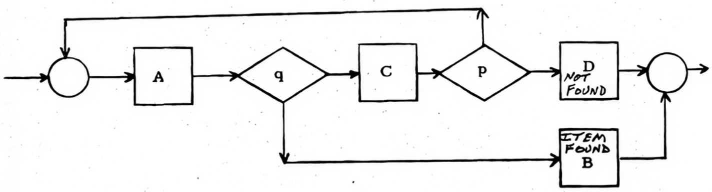
The search macros are used to generate the logic which is typical to what a programmer does when he sets up a loop to search through a table. The programmer's intent is to exit when he finds what he is searching for and perform process B. If he does not find what he is looking for, he executes process D before joining the alternate path. The ORELSE is optional and if it is omitted, box C does not appear in the flowchart. The following shows the format of the STRTSRCH format.

```
STRTSRCH  { WHILE } , (condition), { OR  } [, REG=]
          { UNTIL }                 { AND }
                                    { DO  }
```

The STRTSRCH macro used the WHILE/UNTIL field to generate a WHILE or UNTIL macro statement. The condition format is the same as the WHILE and UNTIL macro.

EXAMPLE

```
STRTSRCH condition p
   Process A
EXITIF condition q
   Process B
ORELSE
   Process C
ENDLOOP
   Process D
ENDSRCH
```



Note:

When using these macros care should be taken not to confuse the ENDLOOP and ENDSRCH macros. The ENDLOOP is used to define the end of the loop and the ENDSRCH indicates the end of the complete macro set.

If a programmer is nesting these macros, he must be certain that each macro set is completely embedded within the process boxes of the higher level ones. If the user does not do this the following sequence of code would generate incorrect branching because of the manner in which the stacks are manipulated.

NAME - TMBIT

PURPOSE

The function of the TMBIT macro is to generate a test under mask instruction which utilizes the length code of the symbol to be tested as the mask byte.

DEFINITION

| | | |
|---|---|---|
| [symbol] | TMBIT | Symbol |

where Symbol is the label of a data base definition which has an associated length code.

EXPANSION

| NAME | OPERATION | OPERAND |
|---|---|---|
| [symbol] | TMBIT | LABEL |
| +[symbol] | TM | LABEL, L'LABEL |

GENERAL NOTES

- The TMBIT macro will be utilized most often in conjunction with the BIT macro, since BIT generates a desired length code associated with a valid label.

NAME - UNTIL

DESCRIPTION

The function of the UNTIL macro is to generate the labels and instructions that branch to these labels to accomplish the programming function of iteration. The UNTIL macro supports both instruction for incrementing/decrementing indexes and instructions for terminating the loop based upon a change in a logical condition. The UNTIL statements support loops in which the indexing/condition-testing instructions are executed after the first pass through the code-body.

The UNTIL MACRO specifications: There are three difference UNTIL statements, the UNTIL-DO, UNTIL-OR-DO, and the UNTIL-AND-DO. For the flowcharts of the UNTIL statements, see the ENDDO macro writeup.

The general format for the UNTIL-DO is:

a. Indexed - UNTIL-DO:

```
UNTIL (index-instructions), DO
  code-body
ENDDO
```

which reads "UNTIL the following index-instructions fail to branch, continue to execute the code-body."

b. Logical - UNTIL-DO:

```
UNTIL (condition), DO
code-body
ENDDO
```

which reads "UNTIL the following conditions are true, continue to execute the code-body."

The general format for the UNTIL-OR-DO is:

```
UNTIL (index-instruction), OR
UNTIL (index-instruction), DO

code-body

ENDDO

UNTIL (condition), OR
UNTIL (condition), DO

code-body

ENDDO

UNTIL (index-instruction), OR
UNTIL (condition), DO

cody-body

ENDDO
```

The general format for the UNTIL-AND-DO is:

```
UNTIL (index-instruction),AND
UNTIL (index-instructions),DO

   code-body

ENDDO

UNTIL (condition),AND
UNTIL (condition),DO

   code-body

ENDDO

UNTIL (index-instruction),AND
UNTIL (condition),DO

   code-body

ENDDO
```

The following shows the format of UNTIL:

```
                                                  ( (R2)       )
          [ BCT  ]                                | LABEL2     |
          [ BXH  ]                                | ONE(S)     |
          [ BXLE ]                    ( (R3) )    | OVERFLOW   |
          [  *   ]                    | IS   |    | PLUS       |
          [ BIT  ]                    | GT   |    | MINUS      |    ( OR  )
UNTIL  (  [  B   ]        (R1)        | LT   |    | MIXED      |    | AND |   [,REG=]
          [  H   ]       LABEL1,      | GE   | ,  | ZERO(S)    | ), ( DO  )
          [  F   ]                    | LE   |    | NMINUS     |
          [  E   ]                    | EQ   |    | NPLUS      |
          [  D   ]                    ( NE   )    | NONE(S)    |
          [  C   ]                                | NZERO(S)   |
          [  T   ]                                | OFF        |
                                                  ( ON         )

                                                     ( OR  )
UNTIL  ([TYPE], LABEL, OPERATION, CONDITION),        | AND |  [,REG=]
                                                     ( DO  )
```

## INDEXED UNTIL

The different types are:

1. BCT:

UNTIL (BCT,R1),{OR / AND / DO}

Example:

```
         UNTIL  (BCT,$1),DO
+LABEL1  EQU *

CODE-BODY

ENDDO
+ BCT  $1,LABEL1
```

2. BXH and BXLE:

UNTIL ({BXH / BXLE},R1,R3),{OR / AND / DO}

Examples:

```
         UNTIL  (BXH,$1,$3),DO
+LABEL1  EQU  *

CODE-BODY

ENDDO
+ BXLE  $1,$3,LABEL1
```

LOGICAL UNTIL

The different types are:

1. An * in the type field stands for the condition is already set. When using the * type, the Operation and Condition fields cannot be omitted.

   Example:

```
         UNTIL  (*,,IS,PLUS),DO
+LABEL   EQU    *

   CODE-BODY

   ENDDO
+  BC       13,LABEL
```

2. Bit type: will generate a test under mask. The only valid operation parameter is (IS).

$$\text{UNTIL (BIT,LABEL,IS,}\left\{\begin{matrix}\text{ZERO}\\\text{ONE}\\\text{ON}\\\text{OFF}\\\text{MIXED}\\\text{NONE}\\\text{NZERO}\\\text{NMIXED}\end{matrix}\right\}\text{),}\left\{\begin{matrix}\text{OR}\\\text{AND}\\\text{DO}\end{matrix}\right\}$$

   Example:

```
         UNTIL   (BIT,A,IS,ZERO),DO
+LABEL1  EQU     *

   CODE-BODY

   ENDDO
+  TM    A,L'A
+  BC    7,LABEL1
```

3. **B Type**

```
                          ( ZERO(S)  )
                          ( PLUS     )
                          ( MINUS    )     ( OR  )
UNTIL  (B,LABEL1,IS,      { NPLUS    } ),  { AND }
                          ( NMINUS   )     ( DO  )
                          (          )
                          ( NZERO(S) )
```

```
                        (    )    ( T'     )
                        ( GT )    ( L'     )
                        ( LT )    ( X'4F'  )
                        ( EQ )    ( C'FF'' )     ( OR  )
UNTIL  (B,LABEL1,       { NE } ,  { B'01'  } ),  { AND }  [,REG=]
                        ( GE )    ( LABEL2 )     ( DO  )
                        ( LE )    ( (R2)   )
```

[REG=] DEFAULTS TO $0.

Examples:

```
        UNTIL  (B,A,IS,ZERO),DO
+LABEL  EQU     *

   CODE-BODY

   ENDDO
+  CLI        A,X'00'
+  BC         7,LABEL

        UNTIL  (B,A,EQ,AAAAAAAA+16),DO
+LABEL   EQU    *

   CODE-BODY
```

```
      ENDDO
+     IC        $0,AAAAAAAA+16
+     STC       $0,*+5
+     CLI       A,X'00'
+     BC        7,LABEL

          UNTIL   (B,A,EQ,($1)),DO
+LABEL    EQU     *

      CODE-BODY

      ENDDO
+     STC       $1,*+5
+     CLI       A,X'00'
+     BC        7,LABEL
```

These B forms of the UNTIL statement alters executable code and are not usable if the program is to be reentrant.

```
      UNTIL  (B,ABLE,EQ,BAKER),DO
+L1   DS   0H

      CODE-BODY

      ENDDO
+     CLC       0+ABLE,BAKER
+     BC        8,L1

      UNTIL  (B,ABLE,EQ,($1)),DO
+L1   DS        0H

      CODE-BODY

      ENDDO
+     EX        $1,*+8
+     B         *+8
+     CLI       ABLE,0
+     BC        8,L1
```

Reentrant B TYPE

```
          UNTIL  (B,A,GT,138),DO
+LABEL  EQU    *

      CODE-BODY

      ENDDO
+     CLI      A,138
+     BC       13,LABEL

          UNTIL  (B,A,GT,0+MUD),DO
+LABEL    EQU  *

      CODE-BODY

      ENDDO
+     CLI      A,0+MUD
+     BC       13,LABEL

          UNTIL  (B,A,GT,X'4F'),DO
+LABEL  EQU   *

      CODE-BODY

      ENDDO
+     CLI      A,X'4F'
+     BC       13,LABEL
```

4. **Fixed-Point (H or F)**

```
                            ONE(S)
                            PLUS
                            MINUS
                (R1)        ZERO(S)          OR
UNTIL  ({H}   ,LABEL1, IS, {NZERO(S)}  ),  {AND}  [,REG=]
        {F}                 NMINUS           DO
                            NPLUS
                            NONE(S)

                             GT    LABEL2
                             LT    (R2)
                (R1)         GE    =F'  '        OR
UNTIL  ({H}   ,LABEL1,     { EQ ,{ =H'  ' }  ),{AND} [,REG=]
        {F}                  NE    =X'  '        DO
                             LE    =C'  '
```

REG= Defaults to $0.

```
         UNTIL  (H,A,IS,PLUS),DO
+LABEL   EQU    *

         CODE-BODY

         ENDDO
+        LH     $0,A
+        LTR    $0,$0
+        BC     2, LABEL

         UNTIL  (H,($1),IS,ZERO),DO
+LABEL   EQU    *

         CODE-BODY

         ENDDO
+        LTR    $1,$1
+        BC     7,LABEL
```

```
         UNTIL    (H,A,GT,B),DO
+LABEL    EQU     *

          CODE-BODY

          ENDDO
+         LH      $0,A
+         CH      $0,B
+         BC      13,LABEL

         UNTIL    (H,A,EQ,($1)),DO
+LABEL    EQU     *

          CODE-BODY

          ENDDO
+         CH      $1,A
+         BC      7,LABEL

         UNTIL    (H,($1),EQ,($2)),DO
+LABEL    EQU     *

          CODE-BODY

          ENDDO
+         CR      $1,$2
+         BC      7,LABEL

          UNTIL   (F,A,IS,PLUS),DO
+LABEL    EQU     *

          CODE-BODY

          ENDDO
+         L       $0,A
+         LTR     $0,$0
+         BC      13,LABEL
```

```
         UNTIL    (F,($1),IS,ZERO),DO
+LABEL    EQU     *

          CODE-BODY

          ENDDO
+         LTR     $1,$1
+         BC      7,LABEL

         UNTIL    (F,A,GT,B),DO
+LABEL    EQU     *

          CODE-BODY

          ENDDO
+         L       $0,A
+         C       $0,B
+         BC      13,LABEL

         UNTIL    (F,($1),GT,B),DO
+LABEL    EQU     *

          CODE-BODY

          ENDDO
+         C       $1,B
+         BC      13,LABEL

         UNTIL    (F,A,EQ,($1)),DO
+LABEL    EQU     *

          CODE-BODY

          ENDDO
+         C       $1,A
+         BC      7,LABEL
```

```
         UNTIL   (F,($1),EQ,($2)),DO
+LABEL    EQU    *

          CODE-BODY

          ENDDO
+         CR     $1,$2
+         BC     8,LABEL
```

5. **Floating Point (E or D)**

```
                                 ⎧ ONE(S)   ⎫
                                 ⎪ PLUS     ⎪
                                 ⎪ MINUS    ⎪
                   (R1)          ⎪ ZERO(S)  ⎪    ⎧ OR  ⎫
UNTIL  (⎧E⎫,LABEL1,IS,           ⎨ NZERO(S) ⎬),  ⎨ AND ⎬   [,REG=]
        ⎩D⎭                      ⎪ NMINUS   ⎪    ⎩ DO  ⎭
                                 ⎪ NPLUS    ⎪
                                 ⎩ NONE(S)  ⎭

                          ⎧ GT ⎫   ⎧ LABEL2 ⎫
                   (R1)   ⎪ LT ⎪   ⎪ (R2)   ⎪    ⎧ OR  ⎫
UNTIL  (⎧E⎫ ,LABEL1,      ⎨ GE ⎬ , ⎨ =E'  ' ⎬),  ⎨ AND ⎬   [,REG=]
        ⎩D⎭               ⎪ EQ ⎪   ⎩ =D'  ' ⎭    ⎩ DO  ⎭
                          ⎪ NE ⎪
                          ⎩ LE ⎭
```

[REG=] Defaults to FPRO.

```
          UNTIL  (E,A,IS,PLUS),DO
+LABEL     EQU   *

          CODE-BODY

          ENDDO
+         LE     FPRO,A
+         LTER   FPRO,FPRO
+         BC     13,LABEL
```

```
         UNTIL    (D,(FPRO),IS,ZERO),DO
+LABEL    EQU      *

          CODE-BODY

          ENDDO
+         LTDR     FPRO,FPRO
+         BC       7,LABEL

         UNTIL    (E,A,GT,B),DO
+LABEL    EQU      *

          CODE-BODY

          ENDDO
+         LE       FPRO,A
+         CE       FPRO,B
+         BC       13,LABEL

         UNTIL    (D,(FPRO),GT,B),DO
+LABEL    EQU      *

          CODE-BODY

          ENDDO
+         CD       FPRO,B
+         BC       13,LABEL

         UNTIL    (E,A,EQ,(FPR2)),DO
+LABEL    EQU      *

          CODE-BODY

          ENDDO
+         CE       FPR2,A
+         BC       7,LABEL
```

```
         UNTIL   (D,(FPRO),EQ,(FPR2)),DO
+LABEL    EQU    *

          CODE-BODY

          ENDDO
+         CDR    FPRO,FPR2
+         BC     7,LABEL
```

6. CHARACTER(C)

```
                          { LT }
                          { GT }               { OR  }
          UNTIL  (C,LABEL1,{ GE } ,LABEL2),    { AND }
                          { EQ }               { DO  }
                          { LE }
                          { NE }
```

```
          UNTIL   (C,ABLE,EQ,BETA),DO
+LABEL     EQU    *

          CODE-BODY

          ENDDO
+         CLC    ABLE,BETA
+         BC     7,LABEL

          UNTIL   (C,=C'SED',EQ,0($3)),DO
+LABEL     EQU    *

          CODE-BODY

          ENDDO
+         CLC    =C'SED',0($3)
+         BC     7,LABEL
```

7. **Test Under Mask (T)**

```
                                    ZERO
                                    ONE
                                    ON
                                    OFF          OR
UNTIL (T,LABEL1, {MASK} , {  MIXED  }),  { AND }
                                    NONE         DO
                                    NZERO
                                    NMIXED
```

```
         UNTIL  (T,A,X'11',ZERO), DO
+LABEL    EQU    *

         CODE-BODY
+        TM     A,X'11'
+        BC     7,LABEL
```

VIII. **Type Field Omitted:**

```
         UNTIL  (,A,IS,ZERO),DO
+LABEL   EQU    *

         CODE-BODY

         ENDDO
+        LE     FPRO,A
+        LTER   FPRO,FPRO
+        BC     7,LABEL
          {
          }
A        DC     E'0'
```

PROGRAMMING NOTES

Also see programming notes for IF macro.

1. "Index-Instruction" can be any one of the following:

   a. BCT,r1
   b. BXH,r1,r3
   c. BXLE,r1,r3

2. "Code-Body" can be any group of valid machine and/or macro instructions, including a maximum of twenty nested WHILE/UNTIL's. Multiple index-instructions in the same loop are also supported.

3. The expansion of the UNTIL macro causes the indexing and/or logical instructions to be assembled after the code-body and executed after the first pass through the code-body.

4. The level of a nested WHILE/UNTIL statement can be found in the LABELS that are generated.

```
         UNTIL        (condition),DO
+UN/5/xxxx  EQU       *
```

   The /5/ stands for the level of this nested UNTIL statement.

5. Any time a register notation is used in a logical-UNTIL statement, the register must be in parentheses. It does not make any difference whether a register is in parentheses or not with an Indexed-UNTIL statement.

6. Misspelling and abbreviation of "conditions" mnemonices is not allowed.

7. Restriction: Expressions cannot be over sixteen characters in length.

8. Reentrant programs that use the B TYPE (BYTE) UNTIL statements should set the global flag <u>&$RENT</u> to 1. This flag will assure that the code generated by the UNTIL macro is reentrant. This reentrant code is slower than the none reentrant code and should be used only in reentrant programs. The global flag has to be defined and set before a CSECT statement. See the examples of the B TYPE UNTIL statement.

Example:

```
       GBLB  &$RENT
&$RENT   SETB  1
XXXXXX  CSECT
           }
```

NAME - WHILE

DESCRIPTION

The function of the WHILE macro is to generate the labels and instructions that branch to these labels to accomplish the programming function of iteration. The WHILE macro supports both instructions for incrementing/decrementing indexes and instructions for terminating the loop based upon a change in a logical condition. The WHILE statements support loops in which the indexing/condition-testing instructions are executed before the first pass through the code-body.

The WHILE MACRO specifications.

There are three different WHILE statements, the WHILE-DO, WHILE-OR-DO, and the WHILE-AND-DO. For the flowcharts of the WHILE statements, see the ENDDO macro writeup.

The general format for the WHILE-DO is:

1. Indexed WHILE-DO:

```
WHILE (index-instruction), DO

     code-body

ENDDO
```

which reads, "WHILE the index-instruction branches, continue to execute the code-body."

2. Logical WHILE-DO:

```
WHILE (condition), DO

     code-body

ENDDO
```

which reads, "WHILE the indicated condition is true, continue to execute the code-body."

The general format for the WHILE-OR-DO is:

```
WHILE (index-instruction), OR
WHILE (index-instruction), DO

     code-body

ENDDO

WHILE (condition), OR
WHILE (condition), DO
```

```
        code-body

    ENDDO

    WHILE (index-instruction), OR
    WHILE (condition), DO

        code-body

    ENDDO
```

The general format for the WHILE-AND-DO is:

```
    WHILE (index-instruction), AND
    WHILE (index-instruction, DO

        code-body

    ENDDO
```

```
WHILE  (condition),AND
WHILE  (condition),DO

   code-body

ENDDO

WHILE  (index-instruction),AND
WHILE  (condition),DO

   code-body

ENDDO
```

The following shows the format of WHILE:

```
                                               (R2)
           BCT                                 LABEL2
           BXH                                 ONE(S)
           BXLE                  (R3)          OVERFLOW
            *                    IS            PLUS
           BIT        (R1)       GT            MINUS              OR
WHILE    ( B      ,   LABEL1,    LT      ,     MIXED         ),   AND    [,REG=]
           H                     GE            ZERO(S)            DO
           F                     LE            NMINUS
           E                     EQ            NPLUS
           D                     NE            NONE(S)
           C                                   NZERO(S)
           T                                   OFF
                                               ON

                                                          OR
WHILE  ([TYPE], LABEL, OPERATION, CONDITION),             AND    [,REG=]
                                                          DO
```

INDEXED WHILE

The different types are:

1. BCT

```
                        OR
   WHILE  (BCT,R1),     AND
                        DO
```

Example:

```
              WHILE     (BCT,$1),DO
+              B        LABEL1
+LABEL2        EQU      *

               CODE-BODY
               ENDDO
+LABEL1        EQU      *
+              BCT      $1,LABEL2
```

2. BXH and BXLE

```
WHILE ( BXH  ,R1, R3), { OR  }
        BXLE           { AND }
                       { DO  }
```

Examples:

```
              WHILE     (BXH,$1,$3),DO
+              B        LABEL1
+LABEL2        EQU      *

               CODE-BODY

               ENDDO
+LABEL1        EQU      *
+              BXH      $1,$3,LABEL2

              WHILE     (BXLE,$1,$3),DO
+              B        LABEL1
+LABEL2        EQU      *

               CODE-BODY

               ENDDO
+LABEL1        EQU      *
+              BXLE     $1,$3,LABEL2
```

LOGICAL WHILE

The different types are:

1. An * in the type field stands for the condition is already set. When using the * type, the Operation and Condition fields cannot be omitted.

Example:

```
         WHILE   (*,,IS,PLUS),DO
+        B       LABEL1
+LABEL2  EQU     *

         CODE-BODY

         ENDDO
+LABEL1  EQU     *
+        BC      2,LABEL2
```

2. Bit type: will generate a test under mask. The only valid operation parameter is (IS).

```
                           ⎧ZERO  ⎫
                           ⎪ONE   ⎪
                           ⎪ON    ⎪   ⎧OR ⎫
WHILE  (BIT,LABEL,IS,      ⎨OFF   ⎬), ⎨AND⎬
                           ⎪MIXED ⎪   ⎩DO ⎭
                           ⎪NONE  ⎪
                           ⎪NMIXED⎪
                           ⎩NZERO ⎭
```

Example:

```
         WHILE   (BIT,A,IS,ZERO),DO
+        B       LABEL1
+LABEL2  EQU     *

         CODE-BODY
```

```
          ENDDO
+LABEL1   EQU       *
+         TM        A,L'A
+         BC        8,LABEL2
```

3. B Type

```
WHILE  (B,LABEL1,IS, { ZERO(S)  }), { OR  }
                     { PLUS     }   { AND }
                     { MINUS    }   { DO  }
                     { NPLUS    }
                     { NMINUS   }
                     { ONE(S)   }
                     { NZERO(S) }
                     { NONE(S)  }

WHILE  (B,LABEL1, { GT }, { T'     }), { AND }  [,REG=]
                  { LT }  { L'     }   { DO  }
                  { EQ }  { X'4F'  }
                  { NE }  { C'FF'  }
                  { GE }  { B'01'  }
                  { LE }  { LABEL2 }
                          {  (R2)  }
```

[REG=] DEFAULTS TO $0

**Examples:**

```
          WHILE     (B,A,IS,ZERO),DO
+         B         LABEL1
+LABEL2   EQU       *

          CODE-BODY

          ENDDO
+LABEL1   EQU       *
+         CLI       A,X'00'
+         BC        8,LABEL2

          WHILE     (B,A,EQ,AAAAAAAA+16),DO
+         B         LABEL1
+LABEL2   EQU       *
```

```
              CODE-BODY

              ENDDO
+LABEL1       EQU        *
+             IC         $0,AAAAAAAA+16
+             STC        $0,*+5
+             CLI        A,X'00'
+             BC         8,LABEL2

              WHILE      (B,A,EQ,($1)),DO
+             B          LABEL1
+LABEL2       EQU        *

              CODE-BODY

              ENDDO
+LABEL1       EQU        *
+             STC        $1,*+5
+             CLI        A,X'00'
+             BC         8,LABEL2

              WHILE      (B,A,GT,138),DO
+             B          LABEL1
+LABEL2       EQU        *

              CODE-BODY
```

These B forms of the WHILE statement alters executable code and are not usable if the program is to be re-entrant

Reentrant B TYPE:

```
              WHILE  (B,ABLE,EQ,BAKER),DO
+    B        LABEL1
+LABEL2       DS    0H

      CODE-BODY

+LABEL1       DS    0H
+      CLC    0+ABLE,BAKER
+      BC     8,LABEL2

              WHILE  (B,ABLE,EQ,($1)),DO
+      B      LABEL1
+LABEL2       DS    0H

      CODE-BODY

+LABEL1       DS    0H
+      EX     $1,*+8
+      B      *+8
+      CLI    ABLE,0
+      BC     8,LABEL2
```

```
              ENDDO
+LABEL1       EQU          *
+             CLI          A,138
+             BC           2,LABEL2

              WHILE        (B,A,GT,0+MUD),DO
+             B            LABEL1
+LABEL2       EQU          *

              CODE-BODY

              ENDDO
+LABEL1       EQU          *
+             CLI          A,0+MUD
+             BC           2,LABEL2
```

```
          WHILE     (B,A,GT,X'4F'),DO
+         B         LABEL1
+LABEL2   EQU       *

          CODE-BODY

          ENDDO
+LABEL1   EQU       *
+         CLI       A,X'4F'
+         BC        2,LABEL2
```

4. Fixed Point (H or F)

```
                                     ONE(S)
                                     PLUS
                                     MINUS
                  (R1)               ZERO(S)        OR
WHILE   ({H}, LABEL1, IS, {          NZERO(S)  }), {AND}   [,REG=]
          F                          NMINUS         DO
                                     NPLUS
                                     NONE(S)

                         GT     LABEL2
                         LT     (R2)
                 (R1)    GE     =F'   '           OR
WHILE   ({H}, LABEL1, {  EQ }, {=H'   '  }), {AND}   [,REG=]
          F              NE     =X'   '           DO
                         LE     =C'   '
```

[REG=] Defaults to $0.

```
              WHILE     (H,A,IS,PLUS),DO
+             B         LABEL1
+LABEL2       EQU       *

              CODE-BODY

              ENDDO
+LABEL1       EQU       *
+             LH        $0,A
+             LTR       $0,$0
+             BC        13,LABEL2

              WHILE     (H,($1),IS,ZERO),DO
+             B         LABEL1
+LABEL2       EQU       *

              CODE-BODY

              ENDDO
+LABEL1       EQU       *
+             LTR       $1,$1
+             BC        8,LABEL2

              WHILE     (H,A,GT,B),DO
+             B         LABEL1
+LABEL2       EQU       *

              CODE-BODY

              ENDDO
+LABEL1       EQU       *
+             LH        $0,A
+             CH        $0,B
+             BC        2,LABEL2

              WHILE     (H,A,EQ,($1)),DO
+             B         LABEL1
+LABEL2       EQU       *
```

```
         CODE-BODY

         ENDDO
+LABEL1  EQU      *
+        CH       $1,A
+        BC       7,LABEL2

         WHILE    (H,($1),EQ,($2)),DO
+        B        LABEL1
+LABEL2  EQU      *

         CODE-BODY

         ENDDO
+LABEL1  EQU      *
+        CR       $1,$2
+        BC       8,LABEL2

         WHILE    (F,A,IS,PLUS),DO
+        B        LABEL1
+LABEL2  EQU      *

         CODE-BODY

         ENDDO
+LABEL1  EQU      *
+        L        $0,A
+        LTR      $0,$0
+        BC       2,LABEL2

         WHILE    (F,($1),IS,ZERO),DO
+        B        LABEL1
+LABEL2  EQU      *

         CODE-BODY

         ENDDO
+LABEL1  EQU      *
+        LTR      $1,$1
+        BC       8,LABEL2
```

```
               WHILE    (F,A,GT,B),DO
+              B        LABEL1
+LABEL2        EQU      *

               CODE-BODY

               ENDDO
+LABEL1        EQU      *
+              L        $0,A
+              C        $0,B
+              BC       2,LABEL2

               WHILE    (F,($1),GT,B),DO
+              B        LABEL1
+LABEL2        EQU      *

               CODE-BODY

               ENDDO
+LABEL1        EQU      *
+              C        $1,B
+              BC       2,LABEL2

               WHILE    (F,A,EQ,($1)),DO
+              B        LABEL1
+LABEL2        EQU      *

               CODE-BODY

               ENDDO
+LABEL1        EQU      *
+              C        $1,A
+              BC       7,LABEL2

               WHILE    (F,($1),EQ,($2)),DO
+              B        LABEL1
+LABEL2        EQU      *

               CODE-BODY
```

```
         ENDDO
+LABEL2  EQU      *
+        CR       $1,$2
+        BC       7,LABEL2
```

5. **Floating Point (E or D)**

```
                                 { ONE(S)   }
                                 { PLUS     }
                                 { MINUS    }
                (R1)             { ZERO(S)  }     { OR  }
WHILE  ( { E } ,LABEL1,IS,       { NZERO(S) } ),  { AND }  [,REG=]
         { D }                   { NMINUS   }     { DO  }
                                 { NPLUS    }
                                 { NONE(S)  }
```

```
                        { GT }   { LABEL2 }
              (R1)      { LT }   { (R2)   }       { OR  }
WHILE  (  E  ,LABEL1,   { GE },  { =E'  ' } ),    { AND }  [,REG=]
          D             { EQ }   { =D'  ' }       { DO  }
                        { NE }
                        { LE }
```

**[REG=] Defaults to FPRO.**

```
         WHILE    (E,A,IS,PLUS),DO
+        B        LABEL1
+LABEL2  EQU      *

         CODE-BODY

         ENDDO
+LABEL1  EQU      *
+        LE       FPRO,A
+        LTER     FPRO,FPRO
+        BC       2,LABEL2
```

```
         WHILE     (D,(FPRO),IS,ZERO),DO
+        B         LABEL1
+LABEL2  EQU       *

         CODE-BODY

         ENDDO
+LABEL1  EQU       *
+        LTDR      FPRO,FPRO
+        BC        8,LABEL2

         WHILE     (E,A,GT,B),DO
+        B         LABEL1
+LABEL2  EQU       *

         CODE-BODY

         ENDDO
+LABEL1  EQU       *
+        LE        FPRO,A
+        CE        FPRO,B
+        BC        2,LABEL2

         WHILE     (D,(FPRO),GT,B),DO
+        B         LABEL1
+LABEL2  EQU       *

         CODE-BODY

         ENDDO
+LABEL1  EQU       *
+        CD        FPRO,B
+        BC        2,LABEL2

         WHILE     (E,A,EQ,(FPR2)),DO
+        B         LABEL1
+LABEL2  EQU       *

         CODE-BODY
```

```
         ENDDO
+LABEL1  EQU      *
+        CE       FPR2,A
+        BC       7,LABEL2

         WHILE    (D,(FPRO),EQ,(FPR2)),DO
+        B        LABEL1
+LABEL2  EQU      *

         CODE-BODY

         ENDDO
+LABEL1  EQU      *
+        CDR      FPRO,FPR2
+        BC       8,LABEL2
```

6. Character (C)

```
WHILE  (C,LABEL1, { LT } ,LABEL2), { OR  }
                  { GT }           { AND }
                  { GE }           { DO  }
                  { EQ }
                  { LE }
                  { NE }
```

```
         WHILE    (C,ABLE,EQ,BETA),DO
+        B        LABEL1
+LABEL2  EQU      *

         CODE-BODY

         ENDDO
+LABEL1  EQU      *
+        CLC      ABLE,BETA
+        BC       8,LABEL2

         WHILE    (C,=C'SED',EQ,O($3)),DO
+        B        LABEL1
+LABEL2  EQU      *

         CODE-BODY
```

```
          ENDDO
+LABEL1   EQU       *
          CLC       =C'SED',O($3)
+         BC        8,LABEL2
```

7. Test Under Mask (T)

```
                                   ZERO
                                   ONE
                                   ON
                                   OFF              OR
WHILE  (T,LABEL1, {MASK},        { MIXED  }),     { AND }
                                   NONE             DO
                                   NMIXED
                                   NZERO
```

```
          WHILE     (T,A,X'11',ON),DO
+         B         LABEL1
+LABEL2   EQU       *

          CODE-BODY

          ENDDO
+LABEL1   EQU       *
+         TM        A,X'11'
+         BC        8,LABEL2
```

8. Type Field Omitted

```
          WHILE     (,A,IS,ZERO),DO
+         B         LABEL1
+LABEL2   EQU       *

          CODE-BODY

          ENDDO
+LABEL1   EQU       *
+         LE        FPRO,A
+         LTER      FPRO,FPRO
+         BC        8,LABEL2
          }
A         DC        E'O'
```

PROGRAMMING NOTES

Also see programming notes for IF macro.

1. "Index-Instruction" can be any one of the following:

   a. BCT,r1
   b. BXH,r1,r3
   c. BXLE,r1,r3

2. "Code-Body" can be any group of valid machine and/or macro-instructions, including a maximum of twenty nested WHILE/UNTIL's. Multiple index-instructions in the same loop are also supported.

3. The WHILE function causes the indexing instructions to be assembled at the end of the loop but generates a branch past the code-body to cause the indexes to be incremented/decremented before the first pass through the code-body.

4. The level of a nested WHILE/UNTIL statement can be found in the LABELS that are generated.

```
              WHILE     (condition),DO
+             B.        W1/5/xxxx
+W2/5/xxxx
```

   The /5/ stands for the level of this nested WHILE statement.

5. Any time a register notation is used in a logical-WHILE statement, the register must be in parentheses. It does not make any difference whether a register is in parentheses or not with an Indexed-WHILE statement.

6. Misspelling and abbreviation of "conditions" mnemonices is not allowed.

7. Restriction: Expressions cannot be over sixteen characters in length.

8. Reentrant programs that use the B TYPE (BYTE) WHILE statements should set the global flag &$RENT to 1. This flag will assure that the code generated by the WHILE macro is reentrant. This reentrant code is slower than the none reentrant code and should be used only in reentrant programs. The global flag has to be defined and set before a CSECT statement. See the examples of the B TYPE WHILE statement.

Example:

```
         GBLB  &$RENT
&$RENT   SETB  1
XXXXXX   CSECT
           ⌇
```

NAME - XIBIT-OIBIT

PURPOSE

The purpose of the XIBIT and OIBIT macros are to generate an EXCLUSIVE OR IMMEDIATE instruction to invert a specified bit, and an INCLUSIVE OR IMMEDIATE instruction to "turn on" a specified bit, respectively. Both utilize the length code of the symbol to be operated upon.

DEFINITION

| | | |
|---|---|---|
| [symbol] | XIBIT | Symbol |

| | | |
|---|---|---|
| [symbol] | OIBIT | Symbol |

where Symbol is the label of a data base definition having an associated length code.

EXPANSION

| NAME | OPERATION | OPERAND |
|---|---|---|
| [symbol] | XIBIT<br>OIBIT | LABEL |
| +[symbol] | XI<br>OI | LABEL, L'LABEL |

GENERAL NOTES

- The XIBIT and OIBIT macros will be utilized most often in conjunction with the BIT macro, since BIT generates a desired length code associated with a valid label.

# 4. USE WITH RTPM

## 4.1 PRE- AND POST-ASSEMBLY PROCESSORS

The concept of structured programming involves a physically structured program listing as an integral part. In order to automate this (permit source coding to be aligned as per OS standards: columns 1, 10, 16), two processors were written to generate either a structured source listing or a structured assembly listing. The post-assembly processor also optionally deletes unreferenced labels from DSECTs and assembly cross-references.

The pre- and post-assembly processors are invoked by coding the following PARM keyword parameter on the EXEC card which invokes RTPM:

PARM. STEPNAME=',,,,SMTPGASM, SMXRPASM'

and adding the following DD card:

//GSSCPRNT DD UNIT=DISK, SPACE=(TRK, (X, Y))

where X is typically 50 - the largest assembly listing that is expected. This is not the total amount of assembler output that the jobstep will generate.

The program SMTPGASM serves as the linkage between RTPM and the pre-assembly processor. When SMTPGASM receives control from RTPM (this occurs when a GASM control card is used in place of a ASSM control card) register 1 points to the same parameter list that will be passed to the assembler following the LINK to SMTPGASM. Upon receiving control SMTPGASM issues an OPEN (a QSAM get-locate type) on the input source member. It then reads the source member for a card that begins with a "*)" pattern. Upon finding this card it scans this card looking for a valid (whose name is in a table) control ID. If a valid ID is found it LINKs to the associated module, defined in a JOBLIBXX DD card added to the RTPM step.* Otherwise it will continue reading the source cards for a valid ID. If a valid ID is never found SMTPGASM will return to RTPM without any special error condition set.

* This capability is not part of HLAL.

When used to generate a structured source listing, no *) cards need to be included in the source member, but an additional DD card must be added to the step for the pre-assembly processor to place the structured source listing:

//STRUCTUR DD UNIT=DISK,SPACE=(TRK,(X,Y))

where X is typically 5 - the largest single source member that is being used.

If no STRUCTUR DD card is included in the jobstep, no structured source listing will show up on ASMPRINT. Note that when the STRUCTUR DD card is used, ./ GASM must be used in place of ./ ASSM.

The post-assembly processor is used to indent assembled code and eliminate non-referenced labels from assembly listings and cross reference only if SMXRPASM is specified in the PARM field of the EXEC card. REHDRTPM will link to SMXRPASM just after linking to the assembler and prior to a BALR to the collection tape writer. SMXRPASM will be passed the DDNAME of the assembler - written print data set and the DDNAME that the assembler would have used if RTPM was not in post-assembly user exit mode. After execution of SMXRPASM, assembly print will be located on the data set that would have been used if no post-assembly exit has occurred; thus normal RTPM processing can resume after the exit.

SMXRPASM will always produce a structured listing unless a $$$$$$$# is found in the cross-reference. The structured listing will be indented three spaces for each new logical section of code and restored three spaces for each logical section of code that is terminated. In addition a level number will be output to indicate the level of indention on all statements. Wrap-around will occur after the level of indention exceeds three levels.

To initiate the non-referenced labels deletion function of SMXRPASM a $ EQU * card must be included in the source listing at the location the deletion is desired to start. A $$ EQU * would stop the deletion function, a $$$ EQU * would start it again, and a $$$$ EQU * would stop it. At this point it could not be started again. SMXRPASM reads through the assembly listing until finding the cross-reference. If a $ EQU * card has been included in the source listing it will be the first label in the cross-reference. If this $ card is found SMXRPASM builds a table of all cross-reference labels that are referenced or whose definition statement number is outside the $ cards limit. It also builds a table

of the definition statement numbers of all cross-reference labels that are not referenced and whose definition number is in the $ cards limit. Once these tables are built SMXRPASM goes back to the beginning of the assembly listing and deletes all statements whose numbers are in the table built above. In addition if the statement following the deleted statement has a blank or an asterisk in card column one it will also be deleted. In the cross-reference it deletes all labels whose name does not appear in the other table built above.

## 4.2 INVOKING THE HLAL MACROS

To invoke the HLAL common MACROs, the following SYSLIB concatenation is suggested:

```
//SYSLIB   DD   DSN=&TMPSRC, DISP=(SHR, PASS), VOL=REF=*.SYSTEMPS
//         DD   DSN=SYS1.MACHAL, DISP=(SHR, PASS), UNIT=DISK,         X
//                   VOL=SER=PRODSK
//         DD   DSN=(User MACRO Library)
//         DD   DSN=SYS1.MACLIB, DISP=SHR
```

The HLAL MACROs reside on PRODSK (SYS1.MACHAL) and the pre- and post-assembly processors are in SYS1.RTPMLIB.

# IBM HLAL Coding Reference Data

(REF. SKYLAB USERS' GUIDE)

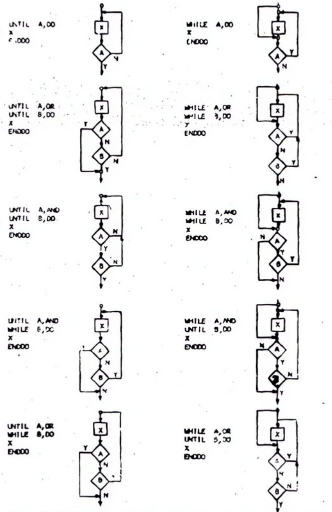
STRUCTURED CODE MACROS

```
IF [{type|•}],{label 1|(R1)},{operation|mask},{condition|label 2|(R2)},{THEN|OR|AND} [,REG=(R3)]
ELSE
ENDIF

UNTIL {(BCT,(R1))
WHILE  ({BXH|BXLE},(R1),(R3)[,(R2)])
       ([{type|•}],{label 1|(R1)},{operation|mask},{condition|label 2|(R2)})} ,{DO|OR|AND} [,REG=(R3)]
ENDDO

STRTSRCH {UNTIL|WHILE}, {UNTIL/WHILE operand}
EXITIF {IF operand}

ORELSE
ENDLOOP
ENDSRCH

DO segment [{,reg|,$14}]

BGNSEG segment[,reg]
ENDSEG segment

[symbol] CASE case reg, {AT=address list|BT=address list|(P)|LAT=address|(R)|LBT=address} [,INDX=number] [,RETREG=register]
```

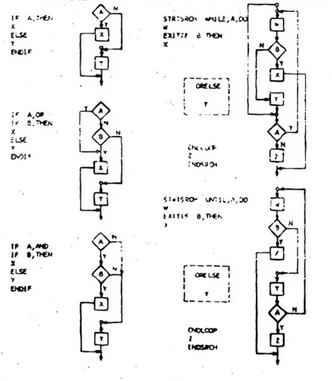
| type | operation/mask | condition/label 2/(R2) |
|---|---|---|
| • | IS | ONE,OVERFLOW,PLUS,MINUS,MIXED,ZERO, NMINUS,NPLUS,NONE,NZERO,NMIXED |
| • | GT,LT,GE,LE,EQ,NE | label 2(,an reg) |
| BIT | IS | ONE,MIXED,ZERO,NONE,NZERO,NMIXED, ON,OFF |
| [illegible] | IS | PLUS,MINUS,[illegible] NMINUS,NPLUS, NZERO |
| [illegible] | GT,LT,GE,LE,EQ,NE | label 2,(R2),[illegible] |
| {B\|?} | IS | ONE,PLUS,MINUS,[illegible],NPLUS, NONE,NZERO |
| {[illegible]} | GT,LT,GE,LE,EQ,NE | label 2,(R2),literal |
| {[illegible]} | IS | ONE,PLUS,MINUS,[illegible],NMINUS,NPLUS, NONE,NZERO |
| {[illegible]} | GT,LT,GE,LE,EQ,NE | label 2,(R2),literal |
| [illegible] | GT,LT,GE,LE,EQ,NE | label 2 |
| [illegible] | mask | ONE,MIXED,ZERO,[illegible],NZERO,NMIXED, ON,OFF |

DATA BASE DEFINITION

```
[symbol] BIT {bit number|(list of bit numbers)|binary 8-bit configuration} [,ON]

[symbol] BYTE [one byte hex value]
```




NOTES: IN AN UNTIL A BCT = YES WHEN THE REGISTER = 0 AFTER EXECUTION OF BCT
IN A WHILE A BCT = NO WHEN THE REGISTER = 0 AFTER EXECUTION OF BCT



MISCELLANEOUS MACROS

```
csectname  HEADC  [INTP=YES][,RET=YES]

[INTP]     ENTER  (csectname,entry2[,entry3,entry4,...])
                  [,(label1,label2,label3,label4,...)]
```

FORMAT OF MATH MACRO

```
[symbol]  MATH  'math expression'[,REG=register list][,TRACE=ON/OFF]
                      (reg)
                [ANS=symbol] [,TYP=E,D,H, or null]
```

MATH REFERENCE SHEET

| OP-CODE | OPERATION | OP-CODE | OPERATION |
|---|---|---|---|
| +, PLUS | ADD | C, WITH | COMPARE |
| -, MINUS | SUBTRACT | TO, COMPARE | COMPARE |
| /, OVER | DIVIDE | | |
| *, TIMES | MULTIPLY | ., LOAD | LOAD |
| | | RELOAD | LOAD |
| =, SAVED-IN | STORE | | |
| STORE, STORE-IN | STORE | XOR | Exclusive OR |
| OR | OR | AND | AND |

| OP-CODE | OPERATION |
|---|---|
| $, HERE= | Place label on next instruction |
| EQU, LABEL= | Place label on next instruction |
| B | Branch on Condition 15 |
| BH, BP | Branch on Condition 2 |
| BL, BM | Branch on Condition 4 |
| BE, BZ | Branch on Condition 8 |
| BO | Branch on Condition 1 |
| BNH, BNP | Branch on Condition 13 |
| BNL, BNM | Branch on Condition 11 |
| BNE, BNZ | Branch on Condition 7 |

VALID OPERAND

Any valid SYMBOL  
Any valid LITERAL  
Any valid REG  
Any valid PREFIXED-EXP  
Any valid TERM  
Any valid NUMBER  
Any valid EXP

| OPERAND | STARTING CHARACTERS |
|---|---|
| NUMBERS | [illegible] 0 — 9 |
| SYMBOL | A — Z, $, and @ (only 8 characters at [illegible]) |
| TERM | A — Z, $, and @ (any assembly language operand) |
| REG | [illegible] followed immediately by a symbol or number |
| EXP | [illegible] followed by at least one blank |
| LITERAL | [illegible] assembly language except quote doubled) |

VALID PREFIXES FOR EXP'S

| | |
|---|---|
| ABS | HALF |
| NEG | DUBL |
| TEST | SQAR |
| COMP | |

SPECIAL TERM FOR SYSTEM PARAMETERS

SYSPARM (MXXXXXNN)  
MXXXXX = SYSPARM NAME  
NN = null or 0 — 99

# 5. EXAMPLE

The following pages present an example of the use of HLAL. First, is the CSECT's structured source listing and second is the same CSECT's structured assembly listing. As discussed previously, both or either the assembled or source structuring may be obtained using the pre- and post-assembly processors with RTPM.

In looking at the source statements, note the effective use of comments with HLAL MACRO statements, producing a much more readable listing.

```
1  2  3           ELSE   ,       ...........THIS IS A NEW POSITION CONTROL WORD
1  2  3  4            L      $0,0($IN)            LOAD THE NPDW INTO GPRO
1  2  3  4            SRL    $0,6
1  2  3  4            SRDL   $0,9
1  2  3  4            SRL    $1,23                GPR1 NOW CONTAINS THE NEW X POSITION
1  2  3  4            N      $0,=X'000001FF'      GPRO NOW CONTAINS THE NEW Y POSITIN
1  2  3  4            S      $0,=F'12'            Y-12
1  2  3  4            SRL    $0,3                 (Y-12)/8
1  2  3  4            MH     $0,=AL2(LMARG+NCCL+RMARG)
1  2  3  4            LR     $3,$0
1  2  3  4            LA     $3,LMARG($3)
1  2  3  4            IF     F,($0),GT,($YMAX),THEN    THIS IS NEW YMAX
1  2  3  4  5              LR     $YMAX,$0
1  2  3  4            ENDIF
1  2  3  4            BCTR   $1,0                 (X-1)
1  2  3  4            SR     $0,$0
1  2  3  4            D      $0,=F'7'             (X-1)/7
1  2  3  4            AR     $3,$1                ((Y-12)/8)*(LINE WIDTH)+LMARG+(X-1)/7
1  2  3  4            IF     F,($3),GT,=A((NLIN-1)*(LMARG+NCOL+RMARG)),THEN
1  2  3  4  5              LA     $15,16          ERROR = BAD X,Y COORDINATE
1  2  3  4  5              B      RSCOMHC    ------------RETURN
1  2  3  4            ENDIF
1  2  3  4*
1  2  3  4*  GPR3 NOW EQUALS THE STARTING DISPLACEMENT INTO THE BUFFER OF THE
1  2  3  4*                        NEXT CHARACTER
1  2  3  4*
1  2  3           ENDIF
1  2  3           LA     $IN,4($IN)        .....POINT $IN TO NEXT WORD.....
1  2           ENDDO
1           ELSE
1  2*
1  2*
1  2*  PUT VECTOR LOGIC HERE
1  2*
1  2*
1           ENDIF
1           WHILE  (F,0($IN),NE,C+COMMAND),DO      ****
1  2           LA     $IN,4($IN)                    *** TEMP
1           ENDDO                                   ****
         ENDDO
         SR     $15,$15              * NO ERRORS IN FORMATTING DATA
         B      RSCOMHC  *-*-*-*-*-* RETURN *-*-*-*-*-*-*-*-*-*-*-*-*-*-*
         SPACE  3
MCVGEBTR DC     X'00'  ********* MCVG TO EBCDIC TR TABLE ***************
         DC     C'1234567890'
         DC     X'000F'
         DC     C'0'                     = OMEGA
         DC     X'10'
         DC     C'/STUVWXYZG/TPDO=JKLMNCPQRIS=*'
         DC     X'2D2E2F'
         DC     C'+ABCDEFGHI(.L*'
         DC     C'3C'
         DC     C'**'
****************************************************************
*   NOTES
*
*   OMEGA (LOWER CAPS)  =  O
*   GAMA                =  G
*   COLON               =  /
*   THETA (CAPS)        =  T
*   PHI   (LOWER)       =  P
*   DELTA (CAPS)        =  D
*   SIGMA (LOWER)       =  S
*   POINTER             =  -
*   ANGLE               =  (
*   LAMBDA  (LOWER)     =  L
*   PSI     (LOWER)     =  X
*   DEGREE              =  *
****************************************************************
         SPACE  3
CHARHIGT DC     F'0'
         SPACE  3
         LTORG
         END
```

```
*****************************************************************  00100000
*                                                                * 00200000
*  FUNCTION -- TO FORMAT THE INPUT MCVG MESSAGE DATA INTO THE CORRECT * 00300000
*              EBCDIC FORM, IN THE OUTPUT BUFFER AREA             * 00400000
*                                                                * 00500000
*  INPUTS ---- GPR1 POINTS TO DOUBLE WORD = ADDR INPUT DATA       * 00600000
*                                           ADDR OUTPUT BUFFER    * 00700000
*                                                                * 00800000
*****************************************************************  00900000
*                                                                  01000000
STRUCTURE HEADC RETRYES                                            01100000
RMARG    EQU   10                 = NO. COLUMNS TO RIGHT OF DISPLAY   01200000
LMARG    EQU   30                 = NO. COLUMNS TO LEFT OF DISPLAY    01300000
NCOL     EQU   72                 = NO. COLUMNS/LINE IN DISPLAY       01400000
NLIN     EQU   62                 = NO. LINES IN OUTPUT DISPLAY       01500000
IMOCW    EQU   X'80'              ... INSERT MEMOR DEVIDE             01600000
EOMCW    EQU   X'40'              ... END OF MESSAGE                  01700000
EMSCW    EQU   X'08'              ... ERASE MEMORY SUBSECTION         01800000
SCCW     EQU   X'04'              ... START SMALL CHARACTERS          01900000
LCCW     EQU   X'02'              ... START LARGE CHARACTERS          02000000
VCW      EQU   X'01'              ... START VECTORS                   02100000
COMMAND  EQU   X'3D'              COMMAND WORD                        02200000
NOINC    EQU   X'10'              NO MEMORY ADDR. INCREMENT           02300000
STRTBLNK EQU   X'0D'              START BLINK                         02400000
STOPBLNK EQU   X'0E'              STOP BLINK                          02500000
$IN      EQU   $10                                                    02600000
$YMAX    EQU   $2                 ... DISP. INTO BUFFER OF LAST LIN   02700000
         SPACE 3                                                      02800000
         L     $IN,0($1)          ... A( INPUT DATA )                 02900000
         L     $11,4($1)          ... A( OUTPUT BUFFER )              03000000
         SR    $YMAX,$YMAX                                            03100000
         SPACE 3                                                      03200000
         WHILE (F,0($IN),NE,0+COMMAND),DO   FIND FIRST CMD WORD       03300000
 1          LA    $IN,4($IN)                                            03400000
         ENDDO                                                        03500000
         SPACE 3                                                      03600000
         WHILE (T,3($IN),X'0'+EMSCW+EOMCW,ZERO),DO  LOOP THROUGH DATA 03700000
 1          IF    B,3($IN),NE,0+VCW,THEN THIS IS NOT A START VECTOR MODE  03800000
 1 2           IF    B,3($IN),EQ,0+SCCW,THEN SIZE = SMALL NOW             03900000
 1 2 3            MVI   CHARWIDT+3,1                                        04000000
 1 2           ELSE                                                         04100000
 1 2 3            IF    B,3($IN),EQ,0+LCCW,THEN SIZE = LARGE NOW            04200000
 1 2 3 4             MVI   CHARWIDT+3,2         SIZE NOW = LARGE              04300000
 1 2 3            END IF                                                    04400000
 1 2           ENDIF                                                        04500000
 1 2           LA    $IN,4($IN)          BUMP $IN PAST CONTROL WORD         04600000
 1 2           WHILE (F,0($IN),NE,C+COMMAND),DC                             04700000
 1 2 3            IF    T,3($IN),X'10',ZERO,CR                              04800000
 1 2 3            IF    T,3($IN),X'2F',NZERO,THEN THIS IS A DATA WORD       04900000
 1 2 3 4             L     $4,C($IN)                                         05000000
 1 2 3 4             LA    $6,5                 = A MAX OF 5 CHAR./WORD      05100000
 1 2 3 4             UNTIL (BCT,$6),DO                                       05200000
 1 2 3 4 5              SRDL  $4,6                                             05300000
 1 2 3 4 5              SRL   $5,26                                            05400000
 1 2 3 4 5              IF    H,($5),EQ,=X'0010',THEN  STOP PROCESSING THIS WORD 05500000
 1 2 3 4 5 6               LA    $6,1                                            05600000
 1 2 3 4 5              ELSE                                                   05700000
 1 2 3 4 5 6               IC    $5,MCVGEBTP($5)                                 05800000
 1 2 3 4 5 6               STC   $5,0($3,$11)                                    05900000
 1 2 3 4 5 6               A     $3,CHARWIDT                                     06000000
 1 2 3 4 5              ENDIF                                                  06100000
 1 2 3 4             ENDDO                                                   06200000
```

```
                                                                                                PAGE    2
OC  OBJECT CODE     ADDR1 ADDR2  STMT   SOURCE STATEMENT                            ASM H V 02 05.09 02/21/72

                                    1 ******************************************************************* C0100000
                                    2 *                                                                 * 00200000
                                    3 *  FUNCTION -- TO FORMAT THE INPUT MCVG MESSAGE DATA INTO THE CORRECT * C0300000
                                    4 *                 EBCDIC FORM, IN THE OUTPUT BUFFER AREA          * 00400000
                                    5 *                                                                 * 00500000
                                    6 *  INPUTS ---- GPR1 POINTS TO DOUBLE WORD - ADDR INPUT DATA       * 00600000
                                    7 *                                       ADDR OUTPUT BUFFER        * 00700000
                                    8 *                                                                 * 00800000
                                    9 *-----------------------------------------------------------------* 00900000
                                   10 *                                                                   01000000
                                   11 SCCWDHCF HEADC RET=YES                                              C1100000
000000                             12+SCCWDHCF CSECT                                                      01-HEACC
000000 47F0 F00C          0000C    13+         B     12(0,15) .     ROUTINE ENTRY POINT REQUIRED IN REG15  01-HEACC
000004 07E2C3D6E6C4C8C3            14+         DC    AL1(7),CL7'SCCWDHCF'                                 X01-HEACC
                                     +                                 PROVIDES ROUTINE NAME IN FORMATED DUMP
00000C 90EC D00C          0000C    15+         STM   14,12,12(13) . SAVES REGISTERS FOR CALLING ROUTINE    01-HEACC
000010 45E0 F06A          0006A    16+         BAL   14,106(0,15)                                          01-HEACC
000014 0000200000000000            17+         DC    X'00002000',F'0',8CL8'SCCWDHCF'                      X01-HEACC
00001C E2C3D6E6C4C8C3C6              +                                  FILLS SAVE WITH CSECT NAME
00005C 58D0 D004          00004    18+RSCCWDHC L     13,4(0,13) .   **PROVIDES A RESTORE OF REGISTERS AND  01-HEACC
000060 58ED 000C          0000C    19+         L     14,12(13) .    RESTORES ALL REGISTERS                 01-HEACC
000064 980C D014          00014    20+         LM    0,12,20(13) .        EXCEPT REGISTER 15               01-HEACC
000068 07FE                        21+         BR    14 .      RETURN TO CALLER WITH B R(CSECT NAME)       01-HEACC
00006A 50D0 F004          00004    22+         ST    13,4(0,14) .  STORES OLD SAVE AREA ADDRESS IN NEW AREA 01-HEACC
00006E 50E0 D008          00008    23+         ST    14,8(0,13) .  STORES NEW SAVE AREA ADDRESS IN OLD     01-HEACC
000072 18DE                        24+         LR    13,14 .       LOADS NEW SAVE AREA ADDRESS IN REG13    01-HEACC
00000014                           25+         USING SCCWDHCF+20,13                                       X01-HEACC
                                     +                         .  ESTABLISHES REG13 AS THE BASE REGISTER

                                   27+*                        GOES THRU REGISTER EQUATE ONLY ONCE
00000000                           28+$0       EQU   0         **                                          02-ECUAT
00000001                           29+$1       EQU   1         **                                          02-ECUAT
00000002                           30+$2       EQU   2         **                                          02-ECUAT
00000003                           31+$3       EQU   3         **                                          02-ECUAT
00000004                           32+$4       EQU   4         **                                          02-ECUAT
00000005                           33+$5       EQU   5         **                                          02-ECUAT
00000006                           34+$6       EQU   6         **IF THESE SUBSTITUTES ARE USED AS          02-ECUAT
00000007                           35+$7       EQU   7         **REGISTER NUMBERS THE CROSS-REFERENCE      02-ECUAT
00000008                           36+$8       EQU   8         **TABLE WILL PROVIDE A LIST OF WHERE        02-ECUAT
00000009                           37+$9       EQU   9         **EACH REGISTER WAS USED                    02-ECUAT
0000000A                           38+$10      EQU   10        **                                          02-ECUAT
0000000B                           39+$11      EQU   11        **                                          02-ECUAT
0000000C                           40+$12      EQU   12        **                                          02-ECUAT
0000000D                           41+$13      EQU   13        **                                          02-ECUAT
0000000E                           42+$14      EQU   14        **                                          02-ECUAT
0000000F                           43+$15      EQU   15        **                                          02-ECUAT
00000000                           44+FPR0     EQU   0                                                     02-ECUAT
00000002                           45+FPR2     EQU   2                                                     02-ECUAT
00000004                           46+FPR4     EQU   4                                                     02-ECUAT
00000006                           47+FPR6     EQU   6                                                     02-ECUAT
```

```
---SCOWDHCF-------SCOWDHCF-------SCOWDHCF-------SCOWDHCF-------SCOWDHCF                                              PAGE    3

 LOC  OBJECT CODE    ADDR1 ADDR2  STMT    SOURCE STATEMENT                                      ASM H V 02 05.09 02/21/72

                                  51+*,********************************,*                                     01-HEADC
                                  52+*,********************************,*                                     01-HEADC
                                  53+*,**       CONTROL SECTION      **,*                                     01-HEADC
                                  54+*,**           SCOWDHCF                **,*                              01-HEADC
                                  55+*,********************************,*                                     01-HEADC
                                  56+*,********************************,*                                     01-HEADC

 0000000A                         58 RMARG     EQU   10               = NO. COLUMNS TO RIGHT OF DISPLAY       C220C000
 0000001E                         59 LMARG     EQU   30               = NO. COLUMNS TO LEFT OF DISPLAY        C130C000
 00000048                         60 NCCL      EQU   72               = NO. COLUMNS/LINE IN DISPLAY           C140C000
 0000003E                         61 NLIN      EQU   62               = NO. LINES IN OUTPUT DISPLAY           C150C000
 00000080                         62 IMDCW     EQU   X'80'            ... INSERT MEMOR DEVIDE                 C160C000
 00000040                         63 EOMCW     EQU   X'40'            ... END OF MESSAGE                      C170C000
 00000008                         64 EMSCW     EQU   X'08'            ... ERASE MEMORY SUBSECTION             C180C000
 00000004                         65 SCCW      EQU   X'04'            ... START SMALL CHARACTERS              C190C000
 00000002                         66 LCCW      EQU   X'02'            ... START LARGE CHARACTERS              C200C000
 00000001                         67 VCW       EQU   X'01'            ... START VECTORS                       C210C000
 0000003D                         68 COMMAND   EQU   X'3D'            COMMAND WORD                            C220C000
 00000010                         69 NCINC     EQU   X'10'            NO MEMORY ADDR. INCREMENT               C230C000
 0000000D                         70 STRTBLAK  EQU   X'0D'            START BLINK                             C240C000
 0000000E                         71 STOPBLNK  EQU   X'0E'            STOP  BLINK                             C250C000
 0000000A                         72 $IN       EQU   $10                                                      C260C000
 00000002                         73 $YMAX     EQU   $2               ... DISP. INTO BUFFER OF LAST LIN       C270C000

 000074 58A1 0000        00000    75           L     $IN,0($1)        ... A( INPUT DATA )                     C290C000
 000078 58B1 0004        00004    76           L     $11,4($1)        ... A( OUTPUT BUFFER )                  C300C000
 00007C 1B22                      77           SR    $YMAX,$YMAX                                              C310C000

                                  79           WHILE (9,0($IN),NE,0+COMMAND),DO    FIND FIRST CMD WORD        C330C000
 00007E 47F0 C072        000C86 1  80+          B     W210003                                                 01-WHILE
 000082                         1  81+W110003   DS    0H                                                      01-WHILE
 000082 41AA 0004        00004  1  82           LA    $IN,4($IN)                                              03400000
                                   83           ENDDO                                                         C350C000
 000086                            84+W210003   DS    0H                                                      01-ENDDC
 000086 953D A000 00000            85+          CLI   0($IN),0+COMMAND                                        01-ENDDC
 00008A 4770 C06E        00C82     86+          BC    7,W110003                                               01-ENDDC

                                   88           WHILE (T,3($IN),K'0'+EMSCW+EOMCW,ZERO),DO   LOOP THROUGH DATA C370C000
 00008E 47F0 C156        0016A  1  89+          B     W210005                                                 01-WHILE
 000092                         1  90+W110005   DS    0H                                                      01-WHILE
                                1  91           IF    B,3($IN),NE,0+VCW,THEN THIS IS NOT A START VECTOR MODE  03800000
 000092 9501 A003 00003           2    92+          CLI   3($IN),0+VCW                                        01-IF
 000096 4780 C146        0015A    2    93+          BC    8,IF10006                                           01-IF
                                  2    94           IF    B,3($IN),EQ,0+SCCW,THEN SIZE = SMALL NOW        C3900000
 00009A 9504 A003 00003           3    95+          CLI   3($IN),0+SCCW                                       01-IF
 00009E 4770 C096        000AA    3    96+          BC    7,IF20007                                           01-IF
```

```
   ---SCWHHCF-------SCCWDHC        3F--------SCOWDHCF-------SCOWDHCF-------SCOWDHCF                         PAGE   4

 LOC  OBJECT CODE   ADDR1 ADDR2       3 STMT   SOURCE STATEMENT                           ASM H V 02 05.09 02/21/72

0000A2 9201 D1AB    001BF             3   97          MVI    CHARWIDT+3,1                                   04000000
                                    2   98          ELSE                                                  04100000
0000A6 47F0 D0A2          0C0B6       3   99+         B      IF20008                                        01-ELSE
0000AA                                3  100+IF20007         DS   0H                                        01-ELSE
                                      3  101          IF     B,3($IN),EQ,0+LCCW,THEN SIZE = LARGE NOW       04200000
0000AA 9502 A003    00003               4  102+          CLI    3($IN),0+LCCW                               01-IF
0000AE 4770 D042          0C0B6         4  103+          BC     7,IF30009                                   01-IF
0000B2 9202 D1AB    001BF       C00     4  104           MVI    CHARWIDT+3,2        SIZE NOW = LARGE        04300
                                      3  105          ENDIF                                                 04400000
0000B6                                3  106+IF30009         DS   0H                                        01-ENDIF
                                    2  107          ENDIF       DS   0H                                     04500000
0000B6                              2  108+IF20008                                                          01-ENDIF
0000B6 41A? 0004          0C0C4     2  109          LA     $IN,4($IN)          BUMP $IN PAST CONTROL WORD    C4600000
                                    2  110          WHILE  (B,0($IN),NE,0+COMMAND),BD                        C4700000
0000BA 47F0 D13?          0C14E       3  111+         B      W220012                                        01-WHILE
0000BE                                3  112+W120012  DS   0H                                               01-WHILE
                                      3  113          IF     T,3($IN),X'10',ZERO,OR                         04800000
0000BE 91I0 A003    0C003             3  114+         TM     3($IN),X'10'                                   01-IF
0000C2 4780 D0B?          0C0CE       3  115+         BC     8,OR20013                                      01-IF
                                      3  116          IF     T,3($IN),X'2F',NZERO,THEN THIS IS A DATA WORD  04900000
0000C6 912F A003    00003               4  117+         TM     3($IN),X'2F'                                 01-IF
0000CA 4780 D0F?          0C1C2         4  118+         BC     8,IF20013                                    01-IF
0000CE                                  4  119+OR20013        DS   0H                                       01-IF
0000CE 5843 0000          0CCC0 C00     4  120           L      $4,0($IN)                                   05000
0000D2 4160 0005          0CCC5 000     4  121           LA     $6,5           = A MAX OF 5 CHAR./WORD      05100
                                C00     4  122           UNTIL  (BCT,$6),RO                                 05200
0000D6                          -UNTIL    5  123+UN30015        DS   0H                                     01
0000D6 8C40 0005          0C0C6 3C0C00  5  124           SRDL   $4,6                                        05
0000DA 8850 001?          0C01A 400000  5  125           SRL    $5,26                                       05
                                500C00  5  126           IF     H,($5),EQ,=X'0010',THEN  STOP PROCESSING THIS WORD  05
0000DE 4950 D1SC          0C190 C1-IF       6  127+          CH     $5,=X'0010'
0000E2 4770 D0F?          0C0FE 01-IF       6  128+          BC     7,IF30016
0000E6 4160 0001          0CCC1 C5600000    6  129           LA     $6,1
                                7C0C00  5  130           ELSE                                               05
0000EA 47F0 D0F6          0CCFA 01-ELSE     6  131+          B      IF30017
0000EE                          01-ELSE     6  132+IF30016         DS   0H
0000EE 4355 D164          0C178 C580000C    6  133           IC     $5,MCVGEBTR($5)
0000F2 4253 5000          0CC00 05SC0000    6  134           STC    $5,0($3,$11)
0000F6 5430 D1?5          0C1BC 06000000    6  135           A      $3,CHARWIDT
                                100C0C  5  136           ENDIF                                              06
0000FA                          -ENDIF    5  137+IF30017         DS   0H                                    01
                                C00     4  138           ENDDO                                              06200
0000FA 4660 D0C?          0C0D6 D00     4  139+          BCT    $6,UN30015                                  01-EN
                                      3  140          ELSE   ,...........THIS IS A NEW POSITION CONTROL WORD    06300000
0000FE 47F0 D136          0C14A SE      4  141+          B      IF20020                                     01-EL
000102                          SE      4  142+IF20013          DS   0H                                     01-EL
000102 5804 0000          0CCC0 C00     4  143           L      $0,0($IN)        LOAD THE NPDW INTO GPRO      06400
000106 8800 0006          0CCC6 C00     4  144           SRL    $0,6                                        06500
00010A 8C00 0009          0CCC9 C00     4  145           SRDL   $0,9                                        06600
00010E 8810 0017          0CC17 C00     4  146           SRL    $1,23            GPR1 NOW CONTAINS THE NEW X POSITION  06700
000112 5400 D1AC          0C1C0 C00     4  147           N      $0,=X'000001FF'  GPRO NOW CONTAINS THE NEW Y POSITIN   06800
000116 5B00 D1?0          0C1C4 C00     4  148           S      $0,=F'12'        Y-12                        06900
00011A 8800 0003          0CC03 CC0     4  149           SRL    $0,3             (Y-12)/8                    07000
00011E 4C00 D1?E          0C1?2 000     4  150           MH     $0,=AL2(LMARG+NCOL+RMARG)                    07100
000122 1830                     C00     4  151           LR     $3,$0                                        07200
```

```
   ---SCOWDHCF-------SCOWDHC  5          4F-------SCOWDHCF--------SCOWDHCF--------SCOWDHCF---                              PAGE

 LOC  OBJECT CODE    ADDR1 ADDR2 /72          4 STMT    SOURCE STATEMENT                                ASM F V 02 C5.09 02/21

000124 4133 001E            000IE C00         4  152          LA     $3,LMARG($3)                                          07300
                                  C00         4  153          IF     F,($0),GT,($YMAX),THEN    THIS IS NEW YMAX            07400
000128 1902                       -IF            5  154+         CR     $0,$YMAX                                              01
00012A 4700 D11C            0C130 -IF            5  155+         BC     13,IF30021                                            01
00012E 1820                       500000         5  156          LR     $YMAX,$0                                              07
                                  000         4  157          ENDIF                                                        07600
000130                            DIF         4  158+IF30021         DS   0H                                               01-EN
000130 0610                       000         4  159          BCTR   $1,0                   (X-1)                          07700
000132 1B00                       C00         4  160          SR     $0,$0                                                 07800
000134 5D00 D1B4            001C8 000         4  161          D      $0,=F'7'               (X-1)/7                        07900
000138 1A31                       000         4  162          AR     $3,$1           ((Y-12)/8)*(LINE WIDTH)+LMARG+(X-1)/7 08000
                                  CC0         4  163          IF     F,($3),GT,=A((NLIN-1)*(LMARG+NCOL+RMARG)),THEN        08100
00013A 5930 D1B8            001CC -IF            5  164+         C      $3,=A((NLIN-1)*(LMARG+NCOL+RMARG))                    01
00013E 4700 D136            0C14A -IF            5  165+         BC     13,IF30023                                            01
000142 41F0 0010            000I0 200000         5  166          LA     $15,16          ERROR = BAD X,Y COORDINATE            08
000146 47F0 D048            0005C 300000         5  167          B      RSCOWDHC  ---------------- RETURN --------------------* 08
                                  000         4  168          ENDIF                                                        08400
00014A                            DIF         4  169+IF30023         DS   0H                                               01-EN
                                       170 *                                                                       08500000
                                       171 *   GPR3 NOW EQUALS THE STARTING DISPLACEMENT INTO THE BUFFER OF THE    08600000
                                       172 *                       NEXT CHARACTER                                  08700000
                                       173 *                                                                       08800000
                                            3  174          ENDIF                                                           08900000
00014A                                      3  175+IF20020          DS   0H                                                 01-ENDIF
00014A 41AA 0004            00004           3  176          LA     $IN,4($IN)       .....POINT $IN TO NEXT WORD.....        09000000
                                          2  177          ENDDO                                                            09100000
00014E                                    2  178+W220012    DS   0H                                                       C1-ENDDO
00014E 9530 A000            00000         2  179+           CLI  0($IN),0+COMMAND                                         C1-ENDDO
000152 4770 D0AA            000BE         2  180+           BC   7,W120012                                                01-ENDDO
                                        1  181          ELSE                                                               09200000
000156 47F0 D146            0015A         2  182+           B    IF10027                                                  01-ELSE
00015A                                    2  183+IF10006          DS   0H                                                 01-ELSE
                                       184 *                                                                       C9300000
                                       185 *                                                                       C9400000
                                       186 *   PUT VECTOR LOGIC HERE                                               C9500000
                                       187 *                                                                       C9600000
                                       188 *                                                                       C9700000
                                        1  189          ENDIF                                                              09800000
00015A                                  1  190+IF10027          DS   0H                                                   C1-ENDIF
                                        1  191          WHILE  (8,0($IN),NE,0+COMMAND),DO        ****                      C9900000
00015A 47F0 D14E            00162         2  192+           B    W220029                                                  01-WHILE
00015E                                    2  193+W120029    DS   0H                                                       01-WHILE
00015E 41AA 0004            00004         2  194          LA     $IN,4($IN)                       *** TEMP                 10000000
                                        1  195          ENDDO                                     ****                     10100000
000162                                  1  196+W220029    DS   0H                                                         01-ENDDO
000162 9530 A000            00000       1  197+           CLI  0($IN),0+COMMAND                                           01-ENDDO
000166 4770 D14A            0015E       1  198+           BC   7,W120029                                                  01-ENDDO
                                       199          ENDDO                                                          10200000
00016A                                 200+W210005    DS   0H                                                      01-ENDDC
00016A 9148 A003            00003      201+           TM   3($IN),X'0'+EMSCW+EOMCW                             01-ENDDC
00016E 4780 D07E            00092      202+           BC   8,W110005                                           01-ENDDC
000172 1BFF                            203          SR     $15,$15            NO ERRORS IN FORMATTING DATA     10300000
000174 47F0 D048            0005C      204          B      RSCOWDHC *-*-*-*-*-* RETURN *-*-*-*-*-*-*-*-*-*-*-*-*-*  10400000
```

```
---SCOWDHCF--------SCOWDHCF--------SCOWDHCF--------SCOWDHCF--------SCOWDHCF--                                    PAGE    6

  LOC  OBJECT CODE    ADDR1 ADDR2  STMT   SOURCE STATEMENT                                        ASM H V 02 05.09 02/21/72

000178 00                           206 MCVGEBTR DC     X'00' ********* MCVG TO EBCDIC TR TABLE **************** 1060C000
000179 F1F2F3F4F5F6F7F8             207          DC     C'1234567890* '                                          1070C000
000185 0D0E                         208          DC     X'0D0E'                                                  10800000
000187 D6                           209          DC     C'O'                   = OMEGA                           1090C000
000188 10                           210          DC     X'10'                                                    1100C000
000189 61E2E3F4F5E6E7F8             211          DC     C'/STUVWXYZ0/TPDD JKLMNOPQR(S '                          1110C000
0001A5 2D2E2F                       212          DC     X'2D2E2F'                                                1120C000
0001A8 4EC1C2C3C4C5C6C7             213          DC     C'+ABCDEFGHI(.L'                                         1130C000
0001B5 F3C4                         214          DC     C'3D'                                                    1140C000
0001B7 5C5C                         215          DC     C'**'                                                    1150C000
                                    216 ***************************************************************************** 1160C0C0
                                    217 *  NCTES                                                                 1170C0C0
                                    218 *                                                                        118CCGCC
                                    219 *  OMEGA (LCWER & CAPS ) =  O                                            119CC0C0
                                    220 *  GAMA                  =  G                                            12C0C000
                                    221 *  CCLCN                 =  /                                            1210C0C0
                                    222 *  THETA (CAPS)          =  T                                            122CC000
                                    223 *  PHI   (LCWER)         =  P                                            1230C0C0
                                    224 *  DELTA (CAPS)          =  D                                            1240C0C0
                                    225 *  SIGMA (LOWER)         =  S                                            125CC0C0
                                    226 *  POINTER               =  -                                            126CC0C0
                                    227 *  ANGLE                 =  (                                            1270C0C0
                                    228 *  LAMBDA (LOWER)        =  L                                            128CC0C0
                                    229 *  PSI   (LCWER)         =  X                                            1290C0C0
                                    230 *  DEGREE                =  *                                            13CCC0C0
                                    231 ***************************************************************************** 1310C0C0

0001B9 000000
0001BC 00000000                     233 CHARWIDT DC     F'0'                                                     1330C0C0

0001C0                              235          LTORG                                                           1350C0C0
0001C0 000001FF                     236                 =X'000001FF'
0001C4 0000000C                     237                 =F'12'
0001C8 00000007                     238                 =F'7'
0001CC 0000[illegible]              239                 =A((NLIN-1)*(LMARG+NCOL+RMARG))
0001D0 0010                         240                 =X'0010'
0001D2 0070                         241                 =AL2(LMARG+NCOL+RMARG)
                                    242          END                                                             1360C000
```

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| SYMBOL | LEN | VALUE | DEFN | REFERENCES | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHARWIDT | 00004 | 0001EC | 0233 | 0057 | 0104 | 0135 | | | | | | | | | | |
| COMMAND | 00001 | 00000030 | 0068 | 0085 | 0179 | 0197 | | | | | | | | | | |
| EMSCW | 00001 | 000000C8 | 0064 | 0201 | | | | | | | | | | | | |
| EDNCW | 00001 | 00000040 | 0063 | 0201 | | | | | | | | | | | | |
| FPR0 | 00001 | 00000000 | 0044 | | | | | | | | | | | | | |
| FPR2 | 00001 | 00000002 | 0045 | | | | | | | | | | | | | |
| FPR4 | 00001 | 00000004 | 0046 | | | | | | | | | | | | | |
| FPR6 | 00001 | 00000006 | 0047 | | | | | | | | | | | | | |
| IF10006 | 00002 | 00015A | 0183 | 0053 | | | | | | | | | | | | |
| IF10027 | 00002 | 00015A | 0190 | 0182 | | | | | | | | | | | | |
| IF20007 | 00002 | 0000AA | 0100 | 0056 | | | | | | | | | | | | |
| IF20008 | 00002 | 0000B6 | 0108 | 0059 | | | | | | | | | | | | |
| IF20013 | 00002 | 0001C2 | 0142 | 0118 | | | | | | | | | | | | |
| IF20020 | 00002 | 00014A | 0175 | 0141 | | | | | | | | | | | | |
| IF30009 | 00002 | 000086 | 0106 | 0103 | | | | | | | | | | | | |
| IF30016 | 00002 | 0000EF | 0132 | 0128 | | | | | | | | | | | | |
| IF30017 | 00002 | 0000FA | 0137 | 0131 | | | | | | | | | | | | |
| IF30021 | 00002 | 000140 | 0158 | 0155 | | | | | | | | | | | | |
| IF30023 | 00002 | 00014A | 0169 | 0165 | | | | | | | | | | | | |
| INNCW | 00001 | 00000080 | 0062 | | | | | | | | | | | | | |
| LCCW | 00001 | 00000002 | 0066 | 0102 | | | | | | | | | | | | |
| LMARG | 00001 | 0000001F | 0059 | 0152 | 0239 | 0241 | | | | | | | | | | |
| MCVGERTC | 00001 | 000178 | 0206 | 0133 | | | | | | | | | | | | |
| NCOL | 00001 | 00000048 | 0060 | 0239 | 0241 | | | | | | | | | | | |
| NLIN | 00001 | 0000003F | 0061 | 0239 | | | | | | | | | | | | |
| NPINT | 00001 | 00000010 | 0069 | | | | | | | | | | | | | |
| OP20013 | 00002 | 0000CF | 0119 | 0115 | | | | | | | | | | | | |
| [illegible] | 00001 | [illegible] | 0058 | 0239 | 0241 | | | | | | | | | | | |
| RSCOMONC | 00004 | 00005F | 0018 | 0167 | 0204 | | | | | | | | | | | |
| SCCW | 00001 | 00000004 | 0065 | 0095 | | | | | | | | | | | | |
| SCOMDHCF | 00001 | 0000C0C0 | 0012 | 0025 | | | | | | | | | | | | |
| STRPBLNK | 00001 | 00000000 | 0071 | | | | | | | | | | | | | |
| STPTBLNK | 00001 | 00000000 | 0070 | | | | | | | | | | | | | |
| UN30015 | 00002 | 000096 | 0123 | 0135 | | | | | | | | | | | | |
| VCW | 00001 | 000000C1 | 0067 | 0092 | | | | | | | | | | | | |
| #110003 | 00002 | 0000E2 | 0081 | 0086 | | | | | | | | | | | | |
| #110005 | 00002 | 000052 | 0090 | 0202 | | | | | | | | | | | | |
| #120017 | 00002 | 00009E | 0112 | 0180 | | | | | | | | | | | | |
| #120029 | 00002 | 00015E | 0193 | 0198 | | | | | | | | | | | | |
| #210003 | 00002 | 000086 | 0084 | 0080 | | | | | | | | | | | | |
| #210005 | 00002 | 00016A | 0200 | 0089 | | | | | | | | | | | | |
| #220017 | 00002 | 00014F | 0178 | 0111 | | | | | | | | | | | | |
| #220029 | 00002 | 000162 | 0196 | 0192 | | | | | | | | | | | | |
| $0 | 00001 | 00000000 | 0028 | 0143 | 0144 | 0145 | 0147 | 0148 | 0149 | 0150 | 0151 | 0154 | 0156 | 0160 | 0160 | 0161 |
| $1 | 00001 | 00000001 | 0029 | 0075 | 0076 | 0146 | 0159 | 0162 | | | | | | | | |
| $10 | 00001 | 0000000A | 0038 | 0072 | | | | | | | | | | | | |
| $11 | 00001 | 0000000B | 0039 | 0076 | 0134 | | | | | | | | | | | |
| $12 | 00001 | 0000000C | 0040 | | | | | | | | | | | | | |
| $13 | 00001 | 0000000D | 0041 | | | | | | | | | | | | | |
| $14 | 00001 | 0000000E | 0042 | | | | | | | | | | | | | |
| $15 | 00001 | 0000000F | 0043 | 0166 | 0203 | 0203 | | | | | | | | | | |
| $2 | 00001 | 00000002 | 0030 | 0073 | | | | | | | | | | | | |
| $3 | 00001 | 00000003 | 0031 | 0134 | 0135 | 0151 | 0152 | 0152 | 0162 | 0164 | | | | | | |
| $4 | 00001 | 00000004 | 0032 | 0120 | 0124 | | | | | | | | | | | |
| $5 | 00001 | 00000005 | 0033 | 0125 | 0127 | 0133 | 0133 | 0134 | | | | | | | | |

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| SYMBOL | LEN | VALUE | DEFN | REFERENCES |
|---|---|---|---|---|
| $6 | 00001 | 00000006 | 0034 | 0121 0129 0139 |
| $7 | 00001 | [illegible] | 0035 | |
| $8 | 00001 | 00000008 | 0036 | |
| $9 | 00001 | 00000009 | 0037 | |
| $IN | 00001 | 0000000A | 0072 | 0075 0082 0082 0085 0092 0095 0102 0109 0109 0114 0117 0120 0143 0178 0176 0179 0194 0194 0197 0201 |
| $YMAX | 00001 | 00000002 | 0073 | 0077 0077 0154 0156 |
| =A(2([illegible]) | 00002 | 0001[illegible]2 | 0241 | 0150 |
| =A([illegible]) | 00004 | 0001CC | 0239 | 0164 |
| =F'12' | [illegible] | [illegible] | 0237 | 014[illegible] |
| =F'7' | 00004 | 0001C8 | 0238 | 0161 |
| =X'000001[illegible]' | 00004 | 0001C0 | 0236 | 0147 |
| =X'0010' | 00002 | [illegible] | 0240 | 0127 |

# BIBLIOGRAPHY

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# PART III STRUCTURING INTERPRETER FOR A MACRO PROCESSING LANGUAGE EXTENSION (SIMPLE)

STRUCTURING INTERPRETER FOR A MACRO PROCESSING LANGUAGE EXTENSION (SIMPLE)

## 1. PURPOSE AND SCOPE

It is the purpose of SIMPLE to reduce the CPU and elapsed time required to expand the HLAL macros, and to extend the capabilities of the present HLAL macros.

SIMPLE is a pre-assembly processor which expands the HLAL statements before they are passed to the Assembler, thus eliminating many accesses of the macro library by the Assembler.

SIMPLE also creates a structured source listing simultaneously with the expansion of the HLAL statements.

The table below is a list of macros supported by the basic SIMPLE pre-as semble processor.

| | |
|---|---|
| BGNCASE | ENDSRCH |
| BGNSEG | ERRETURN |
| BGNWHILE | ERREXIT |
| BSEG | ERRMSG |
| CASE | ESEG |
| DO | EXITIF |
| ELSE | IF |
| ENDALL | INSERT |
| ENDCASE | ORELSE |
| ENDDO | STRTSRCH |
| ENDIF | UNTIL |
| ENDLOOP | WHILE |
| ENDSEG | |

| Approval | Approval |
|---|---|
| | |

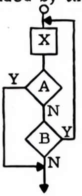
## 2. BACKWARD COMPATIBILITY

All HLAL statements will expand via SIMPLE in exactly the same manner as they would via the macro processor, with these exceptions.

a. The Combination Statement

```
UNTIL  (A), AND
WHILE  (B), DO
   X
ENDDO
```

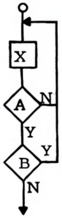
is expanded by the macro processor as,




NOTE: This logic is the same as

UNTIL (A), OR
WHILE (B), DO

But will be expanded by SIMPLE as,



b. The older 'T' type macro is not supported, but the newer, more commonly used 'T' type is supported.

i.e., OLD - IF T, MUD, EQ, '3', THEN
NEW - IF T, MUD, X'3', ZERO, THEN

c. The default registers used in 'IF' type statements are now \$0-\$15 and FPR0-FPR6 rather than 0-15 and 0, 2, 4, 6.

(e.g., L \$0, X rather than L 0, X.)

This notation may be changed via the REG control card (Section 5.2). Equates for the \$ and FPR must be furnished by the programmer.

(e.g., HEADC macro.)

d. If the macros are used incorrectly, the code generated by the HLAL Interpreter Extension may not coincide with the expansion of the HLAL macros. The pre-processor will attempt to create executable structured code by making logical assumptions such as the generation of needed endings (ENDIF, ENDDO, ENDSRCH, ENDLOOP) and the rejection of macros that are out of sequence.

# 3. ADDED CAPABILITIES

## 3.1 USE OF PARENTHESIS

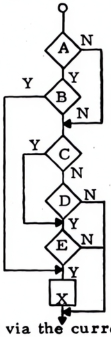
a. Parenthesis may be used or omitted when coding the IF macro.

```
e.g.,    IF  (F,A,GT,B),THEN   or
         IF   F,A,GT,B,THEN
```

b. Parenthesis may be used to form any legal chain of Boolean operations using the IF, WHILE, UNTIL, STRTSRCH macros.

(e.g., the operation (AB) + ((C + D)E) could be coded,

```
IF  (A,AND
IF  B),OR
IF  ((C,OR
IF  D),AND
IF  E),THEN
    X
ENDIF
```




c. Since parenthesis grouping is not supported via the current macro processing, Boolean operations have always expanded in a sequential manner.

e.g., AB + CD is expanded as A(B + CD)

The logical expansion would be (AB) + (CD). In order to maintain backward compatibility, SIMPLE will expand operations without parenthesis in a sequential mode unless logical is specified on an HLALEVEL control card (Section 5.3).

## 3.2 CONDITION CODES AND MASKS

For those occasions when the standard set of HLAL condition code mne-monics (EQ, LE,,, etc.,) do not describe the condition to be tested, a complete set of condition code and mask mnemonica has been added. They are M00 thru M15 and CC0, CC1, CC2, CC3.

e.g., The statement IF (*,,IS, M04), THEN
Expands to BC 11, FALSELAB

## 3.3 ERROR PROCESSING STATEMENTS

One additional parameter has been added to the three error processing macros ERRMSG, ERRENTER, and ERRETURN. This allows the programmer to create more than one entry point for error handling. The new parameter must begin with the character $, and is of the form $X, where X is the name of an additional error entry point (maximum lentgh of X = 57 characters).

The new macro formats and expansions are:

```
                 ERRENTER          $A,$X
+                B        ERREX$X     (if generated)
+ERXT$A          DS       0H
                 ERRMSG            $A,$B,$X
+ERXT$A          BAL      $B,ERREX$X
                 ERRETURN $X
+ERREX$X         DS       0H
```

NOTE: All other rules previously established for these macros remain unchained.

Example:

```
*      Count a million one dollar bills from an input file.

       WHILE
           ERREXIT    (F,(COUNT),LT,MILLION), DO
           GET        A,DOLLAR
           ERREXIT    IF,B,DENOMINATION,GT,ONEDOLLAR,TOOBIG
           ERREXIT    IF,TYPE,EQ,SILVERCERTIFICATE,RECALL
           ERREXIT    IF,PICTURE,NE,WASHINGTON,COUNTERFEIT
           LA         COUNT,1(COUNT)
           BCTR       DOLLARSLEFT,0
       ENDDO
       RETURN

*
*      ERROR PROCESSING
*

           ERRENTER   RECALL
         __CALL       RAREBILLCOLLECTOR
        |  ERRENTER   COUNTERFEIT
        |  CALL       TREASURYAGENT
        |->ERRETURN
           DISABLE    INPUT
           RETURN

*          ERRMSG     OUTOFMONEY,$MSGEXIT
        |--DC         CL50'FILE HAS LESS THAN ONE MILLION DOLLARS'
        |__ERRMSG     TOOBIG,$MSGEXIT
        |  DC         CL50'WRONG SIZE BILLS IN FILE'
        |->ERRETURN   $MSGEXIT
           MVC        MSGAREA(50),0($0)
           PUT        OUT,MSGAREA
           RETURN
```

## 3.4 CASE/BGNCASE/ENDCASE

### 3.4.1 CASE

The CASE macro has the capability of having inline segments. This modification is invoked by the keyword BEGIN which causes a return label to be generated. The BGNCASE and ENDCASE macros have been added to generate both the inline segments and the return label.

### 3.4.2 BGNCASE and ENDCASE

These macros are required for the extended CASE capability. The syntax for these macros is:

a. BGNCASE casename
which will generate -
```
+casename DS     0H
```

b. ENDCASE { ALL / casename }
which will generate -
```
+genlabel   DS     0H - for the ALL option
+           B      genlabel for the "casename" option
```

Example:
```
              CASE       $5,BEGIN,BT=(X,Y,Z)
     +        LA         14,GENLAB01
     +        B          *+4($5)
     +        B          X
     +        B          Y
     +        B          Z
     +        BGNSEG     X
     +X       DS         0H
              .
              .
              .
              ENDSEG     X
     +        BR         $14
              BGNCASE    Y
     +Y       DS         0H
              .
              .
              .
```

```
         ENDCASE      Y
+        B            GENLAG01
         BGNCASE      Z
+Z       DS           0H
         .
         .
         .
         ENDCASE      ALL
+GENLAB  1   DS       0H
```

3.5 INSERT, BSEG, And ESEG

These macros allow the user to segment his code, creating a page effect in his structured source listing. The conditional assembly instructions, AGO and ANOP, are employed to achieve this effect. The syntax for these macros is:

a. INSERT segname
   which will generate -
```
+            AGO     .segname1
+.segname2       ANOP
```

b. BSEG segname
   which will generate -
```
+            AGO     .segname3
+.segname1       ANOP
```

c. ESEG segname
   which will generate -
```
+            AGO     .segname2
+.segname3       ANOP
```

Example: Listing page 1 -

```
                 .
                 .
                 .
                 .

         IF A, THEN
         INSERT     CODE
+        AGO        .CODE1
```

```
+.CODE2     ANOP
            ENDIF
            .
            .
            .
```

Example: Listing page 2 -

```
            .
            .
            .
            BSEG      CODE
+           AGO       .CODE3
+.CODE1     ANOP
            ESEG      CODE
+           AGO       .CODE2
+.CODE3     ANOP
            .
            .
            .
            END
```

NOTE: The segmented code will be assembled inline but will appear separately in the structured source listing.

## 3.6 ENDALL

The ENDALL statement generates, without printing on the structured listings, closings (ENDIF's, ENDDO's, etc.) for previous IF's, WHILE's, etc.

The statement format is:

```
ENDALL      X     where X is the number of logic levels
                  to close. (X = blank, closes all levels.)
```

Example:

```
IF   (A), THEN
     WHILE  (B), DO
          UNTIL  (C), DO
               IF  (D), THEN
                    X
     ENDALL  3  (generates ENDIF, ENDDO, ENDDO)
     WHILE  (E), DO
          IF  (F), THEN
               X
ENDALL          (generates ENDIF, EDDDO, ENDIF)
```

## 4. PROCESSING ASSEMBLER CONTROL INSTRUCTIONS

The ICTL statement is always honored if it is the first statement in the input stream. At the user's option the SPACE, TITLE, and EJECT assembler instructions will also be honored. If they are honored, then spacing or page ejection will occur in the structured data set, and the words SPACE or EJECT will not appear. (See Section 5.1.)

# 5. SIMPLE CONTROL STATEMENTS

SIMPLE control statements may be placed anywhere in the input stream. They are of the format *) OPERATOR OPERAND and consist of several commands.

## 5.1 PRINTER CONTROL FOR THE STRUCTURED DATA SET

*) SPACE {ON / OFF}

*) EJECT {ON / OFF}

*) TITLE {ON / OFF}

If ON is selected, the SPACE, EJECT, or TITLE cards will be honored for the structured listing; otherwise, these cards will be ignored.

*) STRUCTUR {START / STOP}

When the structured listing becomes so deeply nested that one statement will not fit on one print line (120 characters) the remainder or overflow will be printed, right adjusted, on the next line. If the overflow becomes too large, the structured listing may become unreadable. STRUCTUR STOP causes the structure level to be frozen at its current level. The level continues to be maintained internally and structuring will resume at the proper level when the STRUCTUR START command is received.

## 5.2 REGISTER CONTROL

The user may define, for use by the SIMPLE macro processor, symbolic names for any of his general purpose or floating point registers. A prefix symbol(s) may be specified for any or all fixed-point or floating-point registers. It will be the user's responsibility to set up the equates needed for these symbolic parameters.

Operator = REG
Operands = 0 → 15, FPR0 → FPR6, FIX, FLOAT,
where: 1. 0 → 15 is one of the 16 general purpose registers
2. FPR0 → FPR6 is one of the 4 floating-point registers

3. FIX specifies a prefix for all 16 general purpose registers
4. FLOAT specifies a prefix for all floating-point registers

Examples:

*) REG 1=ONE, 2=TWO, 3=THREE
*) REG FIX=GPR, FLOAT=FP
*) REG 0=R1, 1=F1, FLOAT=POINT

Example 1 equates fixed-point registers 1, 2, 3 to ONE, TWO, THREE respectively.
Example 2 equates prefix GPR to all 16 fixed-point registers as follows: GPR0, GPR1, GPR2,..... GPR 15 and FP is prefixed to all floating-point registers
Example 3 is a combination of examples 1 and 2.

NOTE: The default values are $1, $2, $3... $15 and FPR0, FPR2, FPR4, FPR6.

5.3 "IF-TYPE" MACRO PROCESSING

The HLALEVEL macro control card allows the user to specify whether he wants SIMPLE to perform logical or sequential processing on the "IF-TYPE" macros (IF, EXITIF, WHILE, UNTIL, and STRTSRCH)

Operator = HLALEVEL

Operand = {SEQ | LOG}

where: SEQ = sequential processing
LOG = logical processing

"IF-TYPE" statement AB + CD would be handled one of two ways depending on whether the user specified LOG or SEQ.

| | |
|---|---|
| if SEQ | AB+CD=A(B+CD) |
| if LOG | AB+CD=(AB) + (CD) |

NOTE: Default is SEQ.